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PART 1 OF 2

APPENDIX A
RECORD OF DECISION

WHITE KING/LUCKY LASS SUPERFUND SITE RECORD OF DECISION

FREMONT NATIONAL FOREST
LAKEVIEW, OREGON

Prepared by

Office of Environmental Cleanup
EPA Region 10

September, 2001

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PART I: THE DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

The Fremont National Forest/White King and Lucky Lass Uranium Mines (USDA), referred to as the White King/Lucky Lass Uranium Site or "Mines site", is located in Lake County approximately 17 miles northwest of Lakeview, Oregon. The Mines site is in the Lakeview Ranger District of the Fremont National Forest and situated on both National Forest System Land and private property. The Mines site encompasses approximately 140 acres affected by uranium mining activities which occurred during the 1950s and 1960s.

The Environmental Protection Agency (EPA) Identification Number: OR7122307658.

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedy for the Mines site. This Record of Decision (ROD) has been developed in accordance with the requirements of the Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA) of 1980, 42 USC §9601 *et seq.* as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substance Pollution Contingency Plan (NCP), 40 CFR Part 300. This decision is based on the Administrative Record for the Mines site.

The remedy was selected by the U.S. Environmental Protection Agency. The U.S. Department of Agriculture Forest Service ("USFS or Forest Service"), State of Oregon Department of Environmental Quality (ODEQ) and Oregon Office of Energy (OOE) concur with the selected remedy. Their concurrence letters are attached in Appendix E.

ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. Such a release or threat of release may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

This ROD addresses contaminated soils, waste rock, and ground water at the White King and Lucky Lass Mines, and contaminated water and sediments at the water filled excavation pit (pond) located at the White King Mine. The selected remedy includes consolidating and covering of the most highly contaminated soils from both mines at the White King Mine area and continued neutralization of the acidity in the White King pond. Since the pond neutralization could impact the concentrations of contaminants in sediments, and sediment toxicity was not fully evaluated in the RI/FS, the White King pond will be further evaluated to better assess the risks and feasibility of environmental protection for the proposed beneficial uses (aquatic habitat).

The major components of the selected remedy for each area of the Mines site include:

White King Stockpiles

- Recontour the protore[1] stockpile at the White King Mine so it is out of the Augur Creek floodplain. Approximately 138,000 cubic yards of the protore stockpile will be moved and regraded;

- Excavate the overburden stockpile at the White King Mine and contaminated soils which are above background concentrations and exceed health based protective levels in the vicinity of the White King mine, including portions of Augur Creek adjacent to the stockpile, the haul road, and other areas referred to as "off-pile", and consolidate with the recontoured protore stockpile described above. Approximately 465,000 cubic yards of overburden will be excavated;

- Isolate the consolidated stockpile (also referred to as the mine waste repository) under recompacted clay and cap with a two-foot thick clean soil cover in order to support native vegetation;

- Implement long term inspection and maintenance of the mine waste repository to ensure it remains protective;

- Land use restrictions will be put in place to limit and manage human exposure to contaminated soils underneath the mine waste repository cover and underlying groundwater, and any uses that could impact the integrity of the Mine waste cover.

- Access will be restricted by constructing a fence or other physical barrier surrounding the mine waste repository in order to prevent exposure to and disruption or use of the stockpiles materials by human or medium-to-large animals.

- Monitor upgradient and downgradient ground water at the mine waste repository and Augur Creek surface water and sediment to ensure that the proposed beneficial uses of ground water (aquatic life and livestock) are maintained and that the remedy is protective.

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[1] Protore is a mining term for low-grade mineralized materials surrounding an ore. This term was originally used to describe one of the stockpiles at the Mines site. The results of subsequent investigations indicated that both stockpiles consist of overburden (material removed to reach the ore), however, the original terminology was retained to be consistent with previous reports.

White King Pond

- Conduct maintenance on the pond in order to raise the pH in the pond water in order to be protective and meet state water quality standards for Goose Lake Basis (requires a pH range of 7-9).

- Monitor the pond (water and sediments) and ground water (including surface discharge or seeps along the highwall) to determine the effectiveness of pond neutralization, refine background levels, establish trends and further evaluate the risks associated with pond water, seeps, and sediments.

- Conduct an assessment of the toxicity and bioaccumulation potential of COCs in pond sediments to further assess the risks and feasibility of environmental protection for the proposed beneficial uses (aquatic habitat)[2]. If sediments are determined to pose an unacceptable risk to aquatic organisms at the population level which could impact higher trophic levels, action such as sediment capping or dredging may be required. This action will be documented in an Explanation of Significant Decision (ESD) or ROD amendment.

- Implement access restrictions such as fencing to prevent other beneficial uses of the pond which could pose an unacceptable exposure to sediments in the pond (e.g., recreational use, livestock watering).

- Land use restrictions will be put in place to limit and manage use of the pond such as for recreational, or agricultural purposes. Use of the pond water for fire suppression may be allowed in certain circumstances consistent with the Forest Plan Amendment.

Lucky Lass Stockpile

- Excavate soils and waste rock, which are above background concentrations and exceed health based protective levels from the Lucky Lass stockpile and off-pile areas (approximately 3,000 cubic yards), and placement into the White King mine waste repository.

- Regrade remaining soil and waste rock to prevent erosion and promote vegetation. The disturbed areas will be covered with 3 inches of soil.

- Implement institutional controls to prevent removal or residential use of the remaining Lucky Lass stockpile soils and prohibit installation of drinking water wells within the stockpile.

[2] Because the White King pond occurs in a mineralized zone it is uncertain if certain beneficial uses can be fully protected with respect to sediment exposure. This issue is discussed further in Section 12.2.2.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable.

The remedy for the White King Pond, in-situ neutralization, satisfies the statutory preference for treatment as a principal element of the remedy. Neutralization of the pond water increases the pH and reduces the concentration of COCs in the surface water.

The contaminated soils at the Mines site are not principal threat wastes as that term is defined by EPA. Principle threat wastes are source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a significant risk to human health or the environment should exposure occur. The stockpiles at the Mines site are considered to be relatively non-mobile with low toxicity which can be reliably contained. Section 11 of the Decision Summary provides the rationale for the determination that no principle threat wastes exist at the Mines site and Section 10.4.1 describes how treatment was considered during the comparative analysis of alternatives.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record for this Site.

- Chemicals of concern (COCs) and their respective concentrations. (See Section 5.3.1)
- Baseline risk represented by the COCs. (Section 7.1.6)
- Cleanup levels established for COCs and the basis for the levels. (See Section 12.6.1)
- Whether source materials constituting principal threats are found at the Mines site. (See Section 11)
- Current and future land and ground water use assumptions used in the baseline risk assessment and ROD. (See Section 6)

- Potential land and ground water use that will be available at the Mines site as a result of the Selected Remedy. (See Section 12.6)
- Estimated capital, operation and maintenance (O&M), and total present worth costs; discount rate; and the number of years over which the remedy cost estimates are projected. (See Section 12.5)
- Key factor(s) that led to selecting the remedy. (See Section 12.1)

AUTHORIZING SIGNATURE

Michelle Pirzadeh for

Michael F. Gearheard, Director
Environmental Cleanup Office, Region 10
U.S. Environmental Protection Agency

9/28/01
Date

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RECORD OF DECISION
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ABBREVIATIONS AND SYMBOLS

AEC	Atomic Energy Commission
AMW	Acid Mine Water
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Federal Ambient Water Quality Criteria
BSAF	Biota-sediment accumulation factor
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
CRP	Community Relation Plan
COC	Chemical of Concern
COPC	Chemical of Potential Concern
CSF	Cancer Slope Factor
cy	Cubic Yards
DEIS - RI/FS	Draft Environmental Impact Statement - Remedial Investigation/Feasibility Study
DO	Dissolved Oxygen
EPA	U.S. Environmental Protection Agency
EECA	Engineering Evaluation Cost Assessment
EPC	Exposure Point Concentration
ESD	Explanation of Significant Difference
FS	Feasibility Study
FWQC	Federal Water Quality Criteria
gpm	gallons per minute
HEAST	Health Affects Summary Tables
HI	Hazard Index
HQ	Hazard Quotient
I&M	Inspection and Maintenance
IRIS	Integrated Risk Information System
MCL	Maximum Contaminant Level
MOA	Memorandum of Agreement
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
OAR	Oregon Administrative Rule
O&M	Operation and Maintenance
ODEQ	Oregon Department of Environmental Quality
OOE	Oregon Office of Energy
ORP	Oxygen Reduction Potential
ORS	Oregon Revised Statute
OU	Operable Unit
PRP	Potentially Responsible Party
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986

ABBREVIATIONS AND SYMBOLS *(CONTINUED)*

SF	Slope Factor
UCL	Upper Confidence Limit
UTL	Upper Tolerance Level
UMTRCA	Uranium Mill Tailings Radiation Control Act
USFS	United States Forest Service

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PART II: DECISION SUMMARY

INTRODUCTION

This Decision Summary provides a description of the site-specific factors and analysis that led to the selection of the remedy for the White King/Lucky Lass Superfund Site. It includes information about the Mines site Background, the nature and extent of contamination, the assessment of human health and environmental risks, and the identification and evaluation of remedial alternatives.

This Decision Summary also describes the involvement of the public throughout the process, along with the environmental programs and regulations that may relate to or affect the alternatives. The Decision Summary concludes with a description of the selected remedy in this Record of Decision (ROD) and a discussion of how the selected remedy meets the requirements of the Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

Documents supporting this Decision Summary are included in the Administrative Record for the Mines site. Key documents include the Final Remedial Investigation Report, the Final Feasibility Study Report, the Human Health and Ecological Baseline Risk Assessment Report and the Proposed Plan for the Mines site.

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SECTION 1

SITE NAME, LOCATION, AND DESCRIPTION

The White King/Lucky Lass Mines site consists of two former uranium mining areas located in south-central Oregon, approximately 17 miles northwest of Lakeview (**See Figure 1-1**). The Mines site is in the mountains adjacent to the northern boundary of the Goose Lake Valley within the Lakeview Ranger District, Fremont National Forest, Lake County, Oregon. The two mines are located near the edge of upland meadows encompassing portions of Augur Creek at an elevation of approximately 6,000 feet. The White King Mine is situated on the Fremont National Forest, which is managed by the USFS, and also on private lands owned by Fremont Lumber Company, and a Trust. The Lucky Lass Mine is situated 1 mile northwest of the White King Mine above Tamarack Flat. The EPA National Superfund electronic database identification number is OR7122307658.

The Mines site is situated in a remote area. The closest permanent inhabitants to the Mines site live near the intersection of FS 8270 and County Road 16B, approximately 12 miles southeast of the Mines site. The area around the Mines site is used for recreational purposes, including hunting, and snowmobiling. Wood-cutting and cattle grazing also occur in the general area of the Mines site. The major features at the White King Mine include a water-filled excavation pit covering 13.4 acres (pond), a protore stockpile covering 17 acres, an overburden stockpile covering 24 acres, areas where overburden and ore were dumped or spilled during the mining operations including haul roads, and Augur Creek which flows adjacent to the two White King stockpiles (**See Figure 1-2**). The stockpiles contain soil and mineralized rock that were removed from the mine pit. The major features at the Lucky Lass Mine include a 5 acre water-filled excavation pit (pond), a 14 acre overburden stockpile, and an adjacent meadow.

Other features at the Mines site include several collapsed wood frame structures, metal debris, gravel and dirt roads from mining activities, and barbed wire fences currently maintained by the Forest Service. Forest Service Road 3780 is the main road in the area and joins paved county Road 16B approximately 12 miles to the southeast. There are no structures or buildings at the Mines site which are on or eligible to be listed on the National Register of Historic Places.

EPA is the lead regulatory agency for the Mines site and the Forest Service, Oregon Office of Energy (OOE) and Oregon Department of Environmental Quality (ODEQ) are the respective Federal and state support agencies.

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SECTION 2

SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.1 HISTORICAL LAND USE

Both Mines have had several operators, mineral claims holders, leasers and property owners. Mining began at the Mines site in 1955. Initial mining at White King was underground via mine shafts developed up to 312 feet below the surface. In 1959 due to problems with infiltration of water, underground mining was abandoned for open-pit mining techniques which were used until active mining stopped around 1965. Open-pit mining techniques were used from 1956-58 and from 1961-64. An extensive exploratory drilling program was carried on at both Mines through 1979. Since then, little activity has taken place on these claims. Available records indicate the White King Mine produced about 138,146 tons of ore and Lucky Lass produced about 5,450 tons of ore during their period of operation. A total of 140 acres have been disturbed by mining, 120 acres at the White King Mine and 20 acres at the Lucky Lass Mine. Disturbance includes stockpiling of ore and overburden and creation of the water filled White King and Lucky Lass mine pits.

2.2 INVESTIGATION HISTORY

In 1989, the Forest Service began considering action on the mine pits and the stockpiles. In August 1991, the Forest Service issued a draft report titled, "*Draft Environmental Impact Statement Remedial Investigation & Feasibility Study for the Cleanup and Rehabilitation of the White King and Lucky Lass Uranium Mines*" (DEIS-RI/FS)," which evaluates proposed remediation alternatives at the Mines site. This report was revised in 1994 to included expanded discussions, more detailed descriptions, and edits for clarification. It identified placement of all contaminated soils in an upland engineered disposal cell and backfilling the pits with clean material as the preferred cleanup alternatives. Upon review of the 1994 DEIS-RI/FS Report, EPA determined that further investigation and analysis of remedial alternatives were needed to support a remedial action decision under CERCLA.

2.3 ENFORCEMENT HISTORY

The Mines site was added to the National Priorities List (NPL) in April 1995. EPA is the lead regulatory agency for the Mines site and the USFS, Oregon Office of Energy (OOE), and Oregon Department of Environmental Quality (ODEQ) are the respective Federal and State support agencies.

Prior to EPA listing the Mines site on the NPL the USFS was the lead regulatory agency under CERCLA. As discussed in Section 1, The White King Mine is located on both National Forest System land and private property while the Lucky Lass Mine is located solely on National Forest System land. As part of its CERCLA enforcement activities, the USFS performed an investigation into the potentially responsible parties (PRPs) at the Mines site, including issuing requests for information under CERCLA to various individuals and companies in 1991.

The USFS and the State of Oregon entered into a Memorandum of Agreement (MOA) regarding the Mines site in April 1994. This MOA was superceded by a revised Agreement which included EPA as a party and was signed in October 1994. The revised Agreement called for early response actions at the Mines site, and the USFS agreed to perform an Engineering Evaluation/Cost Analysis (EECA) and an action memorandum for a non-time critical removal action at the Mines. The EECA was completed in September 1994 and the removal action was completed in 1995. The USFS initiated site security activities and the stabilization of the stockpiles to prevent erosion. These temporary actions, which were continued until 1995, will be superceded by remedial actions selected in this ROD.

Since the Mines site was included on the NPL in 1995, EPA has been the lead regulatory agency. In April 1995, EPA entered into an Administrative Order on Consent (AOC) with Kerr-McGee Corporation, under which KMC agreed to perform the RI/FS for the Mines site. The administrative order was also signed by the USFS, OOE, and ODEQ as support regulatory agencies. In May 1995, a Memorandum of Understanding was signed between EPA and the USFS to facilitate coordination between the two Federal agencies during the RI/FS. KMC COMPLETED ALL WORK UNDER THE AOC IN JUNE 2000.

EPA continues to work in its lead regulatory role at the Mines site. In July and October 2000, EPA issued follow-up requests for information under CERCLA to PRPs and expects to negotiate cleanup agreements with PRPs after the ROD is issued.

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SECTION 3

COMMUNITY PARTICIPATION

This section summarizes the community relations activities performed by EPA and the USFS during the remedy selection process. EPA and the USFS developed a Community Relations Plan (CRP) for the Mines site in October 1995. The CRP was designed to promote public awareness of cleanup activities and investigations and to promote public involvement in the decision-making process. The CRP summarizes the concerns of local citizens, interest groups, industries, and local government representatives. Community participation activities have included personal interviews, and distribution of fact sheets, newspaper notices, and public notices. During the RI/FS, the USFS and ODEQ were consulted on the anticipated future land uses and potential future ground water uses at the Mines site.

The RI/FS Report and Proposed Plan for the Mines site were made available to the public in September 1999. These documents, along with others that form the basis for the cleanup decisions for the Mines site, can be found in the Administrative Record located at the USFS Lakeview Ranger District Offices, the EPA Region 10 Superfund Records Center at 1200 Sixth Avenue in Seattle, and the Lake County Library at 513 Center Street in Lakeview. Notice of the availability of these two documents was published in the Lake County Examiner on September 29, 1999. On September 29, 1999, a fact sheet and a copy of the proposed plan were mailed to the 100 individuals on the Mines site mail list. A public comment period was held from October 1, 1999 to October 30, 1999. Several extensions to the public comment period were requested and granted until January 10, 2000. A public meeting was held on October 14, 1999 to present the Proposed Plan. Approximately 18 people attended this meeting. During the meeting, representatives from EPA, the USFS, OOE, and ODEQ answered questions about the Mines site, the remedial alternatives, and the preferred alternative. EPA's response to the comments received during this period is included in the Responsiveness Summary, which is part of this ROD.

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SECTION 4

SCOPE AND ROLE OF RESPONSE ACTION

The White King/Lucky Lass ROD addresses the soils, ground water, sediment and surface water at the Mines site.

The remedy selected by EPA and documented in this ROD includes remedial actions necessary to protect human health and the environment. The risk assessment determined that exposures to contaminated soils and ground water pose the greatest risks to human health and the environment. The selected remedy is intended to mitigate or abate the risks posed by Mines site contamination. While contamination will remain on-site, its potential to adversely impact human health and the environment will be mitigated by isolating contaminated soils beneath a soil cover. This will reduce or eliminate any continued migration through erosion which could impact surface water. The soil cover in combination with institutional controls will prevent future human contact with the contaminated soils and the soil cover will reduce potential animal exposure to contamination. The institutional controls will prevent future human contact with shallow ground water beneath the stockpile.

The risk assessment also identified risks to human health and the environment from the White King pond sediments. The remedy selected in this ROD will restrict access to the pond to protect human health and will assess pond sediments to evaluate if action is warranted to address the potential ecological risks. Given the uncertainties associated with the potential ecological risks, the controls in place to restrict human exposure, and the limited aquatic life currently in the pond, sediment cleanup is not warranted at this time. A sediment cleanup action, if determined necessary, will be documented in a future ESD or ROD amendment.

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SECTION 5

SUMMARY OF SITE CHARACTERISTICS

This section summarizes information obtained through the RI/FS. It includes a description of the conceptual site model on which all investigations, the risk assessment, and response actions are based. The major characteristics of the Mines site and the nature and extent of contaminant releases are summarized below. More detailed information is contained in the RI/FS report, which is located in the Administrative Record for the Mines site. See Section 3 for further information on the Administrative Record.

5.1 CONCEPTUAL SITE MODEL

The Conceptual Site Models (Human Health and Ecological) are depicted in **Figures 5-1 and 5-2.** The primary sources of contamination are the soil stockpiles, surface soil, pond water, and pond sediments. The primary release mechanisms are erosion due to wind or water, infiltration, and direct contact. Potential human receptors include recreational users of the Mines site, workers, and potential future residents. Ecological receptors include a variety of plants and animals that are found in the area of the Mines site.

5.2 PHYSICAL CHARACTERISTICS OF THE SITE

5.2.1 Surface Features

The White King/Lucky Lass Mines site is situated in a mountain physiographic setting that forms the northern boundary of Goose Lake Valley. Elevations at the Mines site range from 5,930 to 6,200 feet above mean sea level, with the nearby basalt ridge reaching 6,500 feet above mean sea level. The White King Mine is located west of the northwest-trending Augur Creek; the Lucky Lass mine is located approximately one mile northwest and upgradient of the White King Mine. The Lucky Lass area drains to the Augur Creek valley, intercepting Augur Creek upstream from the White King Mine. The White King Mine also drains to the Augur Creek Valley and Augur Creek.

5.2.1.1 White King Mine

The major surface features at the White King Mine include a 13.4 acre water-filled excavation pit (White King pond), a 85-foot-high wall at the west end of the White King pond, adjacent protore and overburden stockpiles, and smaller areas including haul roads where overburden and ore were dumped or spilled during the mining operations. These features encompass an area of approximately 66 acres.

The White King pond has a teardrop shape, formed from past mining operations. The narrow part of the teardrop was the haul road used to bring material up from the open pit during mining operation. For further information on the water hydrology of the White King pond see Section 5.2.3.2.

The two White King stockpiles were created during mining operations when the former pit (now pond) was being excavated. The protore stockpile covers approximately 17 acres and ranges in thickness from 8 to 27 feet. This stockpile consists of gravel, silt and low permeable layers of clay with a thin layer of gravel at the surface. The protore stockpile contains approximately 542,000 cubic yards of material.

The overburden pile covers approximately 24 acres and ranges in thickness from 7 to 33 feet. Studies on the overburden stockpile indicate that it consists of gravel near the surface with sand and clay material below. The overall nature of the majority of the overburden stockpile is clay-like. The overburden stockpile contains approximately 408,000 cubic yards of material.

A grassy meadow and wetlands separates the two piles. In addition, meadows with wetlands are located just south of the overburden pile and just north of the protore pile. Augur Creek, originating in a spring several miles north of the White King Mine, flows to the southeast along the eastern edge of the piles.

5.2.1.2 Lucky Lass Mine

The Lucky Lass Mine also includes a water-filled excavation mine pit (Lucky Lass pond) and includes an approximate 90-foot-high wall at the south end of the pond, and an adjacent overburden stockpile to the west, east, and north. These features encompass an area of approximately 20 acres. The pond has a teardrop shape similar to the White King pond and is approximately 70 feet deep. For further information on the water hydrology of the Lucky Lass pond, see Section 5.2.3.3. The stockpile rises from about 10 to 40 feet above the natural ground surface with slopes on the edges down to the meadow and Lucky Lass pond. Local relief on the stockpile is about 20 feet. East of the overburden stockpile is a flat grassy meadow containing wetlands. Pond drainage flows into these wetlands. The road network in the area includes a Forest Service road entrance to the stockpile area from the south, and a primitive road entering the meadow from the east, trending north around the mine.

5.2.2 Climate

Since no meteorological data are available for the Mines site, the following discussion is based on conditions observed in Lakeview. Lakeview is located in the semiarid to sub-humid high desert country of the Goose Lake Valley. Overall, this region is characterized by moderate winds (less than 25 mph), cold winters, warm summers, and light precipitation. In Lake County, annual precipitation generally averages from 8 to 10 inches in lower basins, 12 to 16 inches in mountain valleys, and 16 to 25 inches in the forested uplands. The Mines site would be characterized as forested uplands. December and January are the wettest months, with an average precipitation of 2.33 and 2.52 inches respectively. Snowfall accumulation ranges from 20 inches per year in Lakeview to 70 inches per year in the mountains. Snow at the Mines site generally begins to accumulate on the ground in November and may persist until April or May.

5.2.3 Surface Water Hydrology

5.2.3.1 Augur Creek

Augur Creek serves as the major surface drainage in the vicinity of the White King/Lucky Lass Mines site. **Figure 5-3** depicts the Augur Creek watershed at and above the White King Mine. From its headwaters about 3 miles upstream from the White King Mine, Augur Creek is generally confined to a narrow channel. In the vicinity of the White King Mine, the character of the stream changes as the topography flattens. Before mining activities, Augur Creek may have branched into several small channels within the Augur Creek meadow. During the early stages of mining operations, a one-half mile section of Augur Creek near the White King Mine was relocated several hundred feet east to its present day location. Earthen dikes were constructed to maintain this new stream channel. Downstream of the overburden stockpile, Augur Creek generally regains its pre-mining character. Augur Creek stream flow is seasonal with the higher flows experienced during the spring snowmelt and gradually declining through the summer into fall. Flow rates measured near the Mines site during the RI range from a low of 140 gallons per minute (gpm) in October to 3,100 gpm during a June rain event. **Figure 5-4** depicts the modeled location of the 500-year Augur Creek floodplain in the absence of the protore and overburden stockpiles.

5.2.3.2 White King Mine Water Filled Excavation Pit (Pond)

The White King pond was created when surface mining extended below the water table. A significant amount of ground water flowed through fractures in the volcanic tuffs into the underground workings of the mine. In 1978 Western Nuclear dewatered the pond as part of their exploration program. During this dewatering effort the inflow rate was estimated at 200 to 240 gallons per minute. The pond covers an area of approximately 13.4 acres and contains approximately 90 million gallons of water. The deepest part of the pond is approximately 70 feet. The White King pond is fed by surface seeps and springs, and shallow bedrock ground water. The water quality of the White King pond has historically been characterized by a pH in the range of 3 to 4.5, particularly at depth. The low pH is caused by acid generation during oxidation of sulfide minerals exposed in the pond bottoms, walls, and underground mine workings. The pond discharges to a drainage ditch which runs parallel to the overburden stockpile and eventually reaches Augur Creek. Sampling conducted in the pond during the RI suggested that there was no apparent thermal stratification. However, post RI pond sampling indicates thermal stratification during the summer. This stratification results in a pocket of low pH water in the deepest part of the pond. Section 9.3.2 describes the actions taken to neutralize this acidity during 1998 and 1999.

5.2.3.3 Lucky Lass Mine Pond

Lucky Lass pond covers approximately 5 acres and was also created when mining activities extended below the water table. The pond is bounded on the east, west and south sides by a steep highwall of exposed rock. The volume of water in the pond is estimated to be about 5 million gallons. The pond has a continuous discharge that flows from the north end of the pond into the Lucky Lass meadow. The Lucky Lass pond typically has a pronounced thermocline and neutral pH. No remedial action is being taken on the Lucky Lass pond.

5.2.4 Geology

The Mines site is located within the northwest terminus of the Basin and Range province. This area is characterized by north-trending fault-block mountains and basins of internal drainage. Geologic units in the region are characterized by a thick sequence of volcanic flows and volcaniclastic rocks which have been extensively faulted and fractured. Seven geologic units were identified in the surface and subsurface of the White King Mine. They are, from oldest to youngest: older volcaniclastic rocks, rhyolite intrusive and associated tuff breccia, younger and older basaltic flows, younger volcaniclastic rocks and pyroclastics, alluvium, and stockpile. Three geological units were identified in the vicinity of the Lucky Lass Mine. They are from oldest to youngest: volcaniclastic rocks, alluvium and stockpile.

The Lakeview Uranium District includes an area extending 22 miles to the north of Oregon Highway 140 and 17 miles west of Lakeview. This 400-square miles area is host to about 20 uranium occurrences, prospects and past-producing mines. Since the mid-1950s, uranium mineralization has been prospected for and found scattered throughout the district. As discussed in the RI report, numerous uranium-arsenic occurrences and prospects are concentrated within a 50-square-mile section of the Lakeview Mining District. The result of this natural phenomenon is that the entire 50-square-mile area has relatively high geochemical background values in these and other metallic elements relative to the surrounding region. Arsenic levels have been identified up to 1,570 mg/kg and radium-226 at levels up to 9.9 pCi/g in White King meadow soils. These values likely represent the upper end of naturally occurring soil background, based upon information collected during the RI, but were not incorporated into EPA's background calculations for reasons discussed in Section 5.3.1.2.

The major soils in the vicinity of the Mines site are alluvial soils (formed from unconsolidated, detrital sediments) and soils formed from basalt or tuff parent materials, which are generally found on the valley side slopes. The soil that has been most impacted at the Mines site is the alluvial soil associated with Augur Creek fluvial deposits.

5.2.5 Hydrogeology

Ground water flow in the vicinity of the Mines site is primarily controlled by the local and regional topography and geology. The geologic units beneath the Mines site are subdivided into four hydrogeological units: pile or perched, alluvial, shallow bedrock, and deep bedrock. The protore and overburden piles are mineralized with uranium-and metal-bearing sulfide minerals. Perched ground water in the stockpiles is mounded on top of the underlying alluvial unit. Recharge to the stockpile unit is primarily from precipitation and infiltration is primarily downward into the underlying alluvial unit or horizontal out the sides of the stockpiles. The stockpiles are hydraulically connected to the underlying alluvial unit. The mean hydraulic conductivity for the White King stockpile is approximately 4.5 feet per day.

The alluvial unit is recharged directly by precipitation, seeps, and springs from bedrock and locally by Augur Creek. Ground water is lost from the alluvial unit by recharge to Augur Creek and shallow bedrock, and by evapotranspiration. Ground water in the alluvial unit is unconfined. During the spring and early summer months, the alluvial unit can be completely saturated with water. The mean hydraulic conductivity of the White King alluvium is approximately 1.3 feet per day. The water table in the alluvial unit reflects the local topography, with ground water flowing down the valley.

The shallow bedrock unit extends from the ground surface to a depth of 100 feet bgs except where it is overlain by the alluvial unit. Ground water flow in this unit occurs as fracture flow. This unit is recharged by precipitation and the overlying alluvium where present. Ground water in the shallow bedrock unit is unconfined. The mean hydraulic conductivity for the shallow bedrock at the White King mine is approximately 4.8 feet per day. The depth to water in the shallow bedrock in the valleys tends to be shallow (<10 feet), whereas beneath the ridges it can be relatively deep (>50 feet).

The deep bedrock unit is 100 feet or greater below the ground surface. Ground water flow and storage in the deep bedrock unit occurs in fractures. The deep bedrock unit is hydraulically connected to shallow bedrock. Deep ground water probably occurs under semiconfined to confined conditions. The mean hydraulic conductivity of the deep bedrock is approximately 3.6 feet per day at the White King mine.

5.2.6 Natural Resources

The forested area surrounding the Mines site is characterized by mixed-conifer forest dominated by ponderosa pine and white fir, with additional alpine species such as aspen and lodgepole pine. The dominant herbaceous community within the wetlands consists of a combination of hairgrass-sedge moist meadows, sedge-wet meadows, and low sagebrush/bluegrass meadows. The meadow areas downgradient of the Mines site (both Lucky Lass and White King Mines) meet the requirements as wetlands based upon the 1987 Corps of Engineers Wetlands Delineation Manual. However, the exact boundaries of these wetlands have not been field-determined.

The aquatic habitats at the Mines include the White King pond, Lucky Lass pond, the outflow from these ponds, and Augur Creek. Although the historically low pH of the White King Mine pond, due to mining operations, has prevented the development of extensive aquatic life in the pond, the edges of the pond and the surrounding wetland areas contain a variety of aquatic organisms. Aquatic invertebrates (e.g., giant water bugs, ologochaete worms, stoneflies, true fly larvae) and frogs and toads have been identified in all aquatic and wetland habitats. Two species of fish, the redband trout and pit-klamath brook lamprey, have been identified 2 miles downstream of the Mines site and historically had been found in Augur Creek near the Mines site[3]. According to a USFS report (1991b - See references at the end of Section 7.2) a natural 400 foot drop-off downstream of the Mines site prevents migration of fish upstream. This report also identifies several non-mining related impacts (i.e., over-grazing, timber harvesting, road construction/maintenance) which make it unlikely that a cold-water fish population (i.e., salmonids) could live in the creek in the vicinity of the Mines site under current conditions. Also see Section 7.2.1 Risk Assessment - Ecological Setting- which further describes the ecological habitat at the Mines site.

5.3 SUMMARY OF REMEDIAL INVESTIGATION ACTIVITIES

5.3.1 Nature and Extent of Contaminants

As part of the RI, field investigations were conducted from early June to early November 1995 and from June to October 1996. Soil, air, ground water, sediment, and surface water samples were collected in areas upgradient of the Mines site, on and adjacent to the Mines site, and downgradient of the Mines site. Two and three rounds of data were collected in 1995 of ground water and surface water, and additional surface water and ground water samples from selected locations in 1996. (Also see Section 9.3.2 for a discussion of post-RI sampling at the White

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[3] On October 4, 1966 representatives of the Oregon State Board of Health observed over 40 dead trout in Augur Creek downstream of the Mine. Analysis of the discharge from the White King Mine pond showed a pH level of 3.4 and several metallic ions in sufficient concentrations to be lethally toxic when associated with the low pH.

King pond.) In addition to this information, data obtained prior to the RI by the U.S. Forest Service was also used in development of the RI report. The nature and extent of soil, ground water, surface water, and sediment contamination is summarized below and discussed in detail in the RI report. The following discussion focuses on the primary constituents of concern at the Mines site.

5.3.1.1 Air

Two types of RI air monitoring were conducted at the Mines site. The first type was daily ambient air monitoring with a particulate monitor to ensure the safety of the field crew. The second type was a long-term (3-month) monitoring event for ambient radon activities. Action levels for particulates were derived from health risk factors for arsenic, an identified inorganic constituent at the Mines site. Radon levels were compared to the household advisory level of 4 pCi/L. The results indicated that both particulates and radon levels were below action or guidance levels and similar to locations upgradient of the stockpiles.

5.3.1.2 Soils

Several reports have shown that naturally occurring elevated concentrations of arsenic and radium-226 are present in alluvial soils in and around the Mines site. During the RI, several different approaches were used to take this fact into consideration and account for the naturally elevated "background" concentrations found in the vicinity of Mine site. EPA selected preliminary local soil background levels using a 95th percent upper tolerance level of samples that were not adjacent to or under the stockpiles because these samples could have been impacted from mining activities. EPA selected local soil background levels of 6.8 pCi/g radium-226 and 442 mg/kg for arsenic at the White King mine. Local soil background levels also were calculated for the Lucky Lass mine because of different geochemical characteristics of the ore body. The Lucky Lass values for radium-226 and arsenic are 3.6 pCi/kg and 5.4 mg/kg, respectively. Local background was adopted as a Preliminary Remediation Goal (PRG) at both mines except for arsenic at the Lucky Lass mine where the PRG is the arsenic soil standard of 38 mg/kg. These values may need to be re-evaluated during remedial action as more information is collected on background levels underneath or adjacent to the stockpiles.

As part of the RI, individual constituents were evaluated during a preliminary screening to identify primary and secondary constituents of concern in soils and overburden materials. The screening process consisted of comparing the 90 percent upper confidence limit (UCL) concentrations of the detected constituents for various areas of the Mines site to the most stringent available regulatory standard or 5 times the background value if no standard existed. If the 90% UCL concentration was greater than the standard or 5 times the background value, the constituent was selected for evaluation as a contaminant of concern. **Tables 5-1 through 5-8** compare the stockpile materials to standards (if available) or background (native soil near or below the stockpiles and local background) for the various media at the Mines site. (EPA soil screening levels were not used because the Mines site is located in a naturally mineralized area, for which the EPA standards do not account). As a result of this process, 8 constituents were selected for detailed evaluation at the White King Mine: antimony, arsenic, mercury, thallium, uranium-234, uranium-238, radium-226, and thorium-230. Arsenic and Radium-226 were evaluated at the Lucky Lass Mine. **Table 5-1** compares the White King stockpile surface and subsurface soils to background and standards and **Table 5-2** provides this comparison for

Lucky Lass stockpile soil.

White King Protore Stockpile

The average concentration profiles for arsenic and radium-226 in the White King protore stockpile are presented in **Table 5-3.** Elevated concentrations of arsenic correlated closely with activities of uranium-238 and radium-226. The highest concentration of arsenic in the surface soil was 4,140 mg/kg. The highest concentration in surface soil adjacent to the protore stockpile was 895 mg/kg. The highest concentration of arsenic in the subsurface soil in the stockpile was 13,794 mg/kg at a depth of 6 feet. For radium-226 the highest activity in surface soil (collected at 2.5 feet) was 64.6 pCi/g and subsurface soil was 87 pCi/g at approximately 8 feet below the surface.

White King Overburden Stockpile

The average concentration profiles for arsenic in the White King overburden stockpile are also presented in **Table 5-3**. Elevated concentrations of arsenic correlated with elevated activities of uranium-238 and radium-226. The highest concentration of arsenic in the overburden stockpile surface soil was 769 mg/kg. The highest concentration in surface soil adjacent to the stockpile was 822 mg/kg. The highest concentration of arsenic in the subsurface soil within the stockpile was 11,700 mg/kg at a depth of 2.5 feet. The average concentration of arsenic was the greatest in the 2.5 to 5 ft. interval. For radium-226 the highest activity in surface soil (collected at 2.5 feet) was 291 pCi/g. The highest activity in the subsurface was 166 pCi/g collected at approximately 15 feet below the surface.

Lucky Lass Overburden Stockpile

Average concentration profiles for arsenic are presented in **Table 5-3**. The concentration of arsenic at the Lucky Lass Mine is consistently lower than that found at the White King Mine. The highest concentration of arsenic in the surface soil was 11.9 mg/kg and the highest concentration in the subsurface soil within the stockpile was 7.6 mg/kg at a depth of 7.5 feet. The highest concentration of arsenic in the native soil below the overburden stockpile was 17.7 mg/kg at a depth of 3 feet below the stockpile-native soil interface. The highest concentration of arsenic in the surface soil immediately adjacent to the overburden stockpile was 15.0 mg/kg indicating possible erosion of the stockpile material. For radium-226 the highest activity in surface soil was 4.85 pCi/g. The highest activity in subsurface soils was 8.3 pCi/g at a depth of approximately 20 feet below the surface. The highest activity of radium-226 in the surface soil adjacent and nearby the overburden stockpiles was 72.4 pCi/g in the Lucky Lass meadow.

Off-Stockpile Areas

The focus of the RI sampling was on the stockpiles and adjacent "off-pile" areas. There are also other smaller areas where overburden or ore was spilled or dumped during mining operations including haul roads. These areas were characterized with radiation surveys as part of the DEIS-RI/FS. The radiation surveys were designed to map out the areas and depths of greatest radioactive contamination outside the waste piles. The results of these surveys are illustrated in **Figures 11-5 and 11-6** which show a number of areas that potentially exceed cleanup levels.

In summary, arsenic and the radionuclides in the uranium series are the constituents of concern in soils based on their frequency and magnitude of detection. Average arsenic concentrations and radionuclide activities in the White King protore and overburden stockpiles are similar. Arsenic concentrations and radionuclide activities in the Lucky Lass stockpile were significantly less than the White King stockpiles.

The highest activity/concentrations of radionuclides and inorganics are found in the stockpiles. Ground water and subsurface soil sampling data indicate that limited migration has occurred into the soils below the stockpiles. Radionuclide and inorganic activity/concentrations are significantly less in the Lucky Lass stockpile as compared to the White King stockpiles.

5.3.1.3 Surface Water

Augur Creek

During the course of the RI, surface water samples were collected from various locations along Augur Creek. All surface water samples were analyzed for dissolved and total metals, as well as several radium, thorium, and uranium isotopes. Surface water samples were collected from White King and Lucky Lass ponds during 1995-1996.

Table 5-4 provides a comparison of the Augur Creek, Seep, and Drainage Channel Surface Water to background and freshwater chronic EPA Ambient Water Quality Criteria (AWQC). Total arsenic was detected in three of the six surface water sampling stations on Augur Creek. The highest concentration of total arsenic measured in Augur Creek was 41.8μg/L during an August sampling event. None of the detected total arsenic concentration exceeded the AWQC screening criteria of 190 μg/L. No concentrations of total arsenic were detected in surface water from the Lucky Lass drainage channel.

Uranium -234/238 was detected in all samples collected from adjacent and downgradient stations of Augur Creek. The highest RI uranium-234/238 activity measured was 22.5 pCi/L. The highest activity at the farthest downstream sampling location (AC-06) was 6.09 pCi/L. There is no regulatory standard for uranium-234/238 in surface water; however, there is a combined ground water standard (MCL) for uranium-234/238, which is 30 pCi/L. This standard is based upon use of ground water for drinking by humans. None of the surface water samples exceed this ground water standard.

White King and Lucky Lass Ponds

Table 5-5 summarizes the White King and Lucky Lass surface water data and compares it to AWQC. Total arsenic detected in the Mine ponds surface water ranged from 13.9 to 128 μg/L at White King and 9.7 to 17.5μg/L at Lucky Lass. None of these concentrations exceeded the freshwater chronic AWQC established for this constituent (190 μg/L).

Uranium-234/238 was detected during all rounds of RI surface water sampling in the White King pond and ranged from 10.82 to 15.69 pCi/L. Uranium-234/238 also was detected in samples at the Lucky Lass pond. The highest activity detected was 0.83 pCi/L. None of these values exceeded the combined ground water MCL for uranium-234/238 of 30 pCi/L.

Total zinc was detected during all rounds of surface water sampling in the White King pond and ranged from 121 to 157 µg/L. Total zinc concentrations measured in all samples slightly exceeded the freshwater chronic AWQC of 110µg/L.

The White King pond pH has historically ranged from 3 to 4.5 due to acid generation during oxidation of sulfide minerals exposed in the pond bottom, walls, and underground mine workings. The Lucky Lass pond pH values range from 7 to 7.5. Natural surface waters typically have a pH of 7.0. The state water quality standard for the Goose Lake Basin is a pH range of 7-9.

5.3.1.4 Sediments

Augur Creek and Lucky Lass Drainage

Table 5-6 summarizes the Augur Creek and drainage channel sediment data and compares it to background (when no water quality criteria exists) and Ontario Ministry of the Environment (OME) Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario (Persaud et al., 1993) Lowest Effect Level. Canadian guidelines were used as invertebrate effect criteria because of the absence of readily available U.S. criteria for freshwater sediments. Arsenic was detected in five of the six sediment samples collected from the upgradient Augur Creek stations and ranged from 1.9 to 4.2 mg/kg, below the OME guidelines for arsenic (6mg/kg). Sediment samples collected adjacent to the stockpiles and downgradient detected arsenic at concentrations exceeding the screening guidelines. Samples collected adjacent to the Mines site show an increase in arsenic concentrations (25.4 and 159 mg/kg). Concentrations in Auger Creek declined with distance from the Mines site. Concentrations of arsenic in the Lucky Lass drainage channel (6.5 mg/kg) were only slightly above background and the screening criterion of 6 mg/kg.

Other constituents that were either above background or the screening standard were manganese, Uranium-234 and -238.

White King and Lucky Lass Ponds

Table 5-7 provides a summary of the White King and Lucky Lass pond sediment data and compares it to the OME guidelines. Arsenic was detected in all sediment samples collected from the White King pond. Concentrations ranged from 196 mg/kg to 55,600 mg/kg which exceed the Ontario Ministry screening criteria of 6 mg/kg. Arsenic concentrations in the Lucky Lass pond were much lower and ranged from 0.68 to 6.7 mg/kg, which is only slightly above the screening standard.

Radium-226 was detected in all sediment samples collected from the White King pond. Radium-226 ranged from 1.39 to 115 pCi/g. At Lucky Lass pond, the activity ranged from 4.55 to 18.3 pCi/g. Sediment quality criteria are not available for radionuclides and there were no sediment chemistry data from a background pond for comparison.

Other constituents detected above background or a screening standard were iron, lead, manganese, mercury, and nickel.

5.3.1.5 Ground water

Individual ground water sample results were compared to ground water maximum contaminant limits (MCLs) or to a screening concentration based on five-times background concentrations when no MCL existed. MCLs are appropriate for water that will be used for drinking. In the case of radium and uranium, these values were compared to the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) ground water standard which is also based on use of the water for drinking since no MCL existed for uranium at the time of the RI. In December 2000 an MCL for uranium was finalized at 30 µg/L. As a result of this process, arsenic and three radionuclides were identified as primary constituents of concern based on their likelihood of detection at the Mines site. **Table 5-8** provides a comparison of stockpile and off-stockpile ground water results to MCLs and background. The following conclusions are based on the ground water data:

- Radionuclide and inorganic ground water concentrations were highest in samples from monitoring wells in the perched water in the stockpiles and significantly lower in monitoring wells completed off pile and below the stockpiles. There was one exception to this trend in one shallow bedrock well located immediately below the White King protore stockpile which had a uranium concentration of 75 pCi/L which is above the UMTRA standard and 3 orders of magnitude greater than a bedrock well at the overburden stockpile.
- The pH values in all bedrock wells were within the typical ground water pH range while the stockpile (or perched water wells) were significantly lower.
- There were no exceedances of the MCL for uranium-234/238 in the off-pile alluvial, shallow bedrock, or deep bedrock wells, including the wells downgradient of the stockpiles.
- There were no exceedances of the MCL for radium-226/228 in the stockpile, alluvial, and deep bedrock wells. There were two exceedances (5.03 and 15.37 pCi/L) of the standard (5 pCi/L) in the shallow bedrock wells.
- Radon concentrations are elevated and exceed the proposed MCL at nearly all locations, including background wells and deep bedrock wells. This is a result of naturally occurring uranium mineralization in the area.
- Ground water concentrations in the vicinity of the White King Mine are slightly higher than ground water concentrations in the vicinity of the Lucky Lass Mine.

The following provides a more detailed discussion on the primary Chemicals of Concern:

Arsenic

Arsenic concentrations in the protore stockpile wells ranged from 24.4 to 164 µg/L. Arsenic concentrations in the shallow bedrock well below the protore stockpile ranged from 19,100 to 21,900 µg/L. Arsenic concentrations in the overburden stockpile wells ranged from 392 to 36,500 µg/L. Arsenic concentrations in the shallow bedrock wells below the overburden stockpile were much lower, ranging from 10.6 to 486 µg/L. The highest concentrations in deep bedrock ground water samples at White King ranged from 10.8 to 37.6 µg/L.

At Lucky Lass, shallow downgradient bedrock wells ranged from non-detect for arsenic to 3.1 µg/L. Deep bedrock wells at Lucky Lass ranged from 9.7 to 19 µg/L. The ground water standard for arsenic is 50 µg/L.

Uranium-234/238

At White King, the highest combined uranium-234/238 activities were detected in mounded ground water samples collected in the protore stockpile and ranged from 27,300 and 43,600 pCi/L, which is greater than the UMTRCA ground water protection standard of 30 pCi/L. Activities in the overburden stockpile were much less and ranged from 0.5 to 17.8 pCi/L. There were no exceedances of the combined ground water guidance for uranium 234/uranium-238 in the off-pile alluvial, shallow bedrock, or deep bedrock wells, including the wells downgradient of the stockpiles.

Of the five shallow wells at Lucky Lass, uranium-234/238 was only detected in one downgradient well at activities of 4.16 and 4.22 pCi/L. The ground water standard for uranium is 30 pCi/L.

Radium-226, Radium 228

At White King there were no exceedances of the combined ground water guidance value for radium-226/radium-228 in the stockpile, alluvial, and deep bedrock wells. There were two exceedances (5.03 and 15.37 pCi/L) of this standard (5 pCi/L) in the shallow bedrock wells.

At Lucky Lass, shallow bedrock well concentrations ranged from 1.28 to 5.03 pCi/L which are less than or at the 5 pCi/L standard.

Radon

The proposed Drinking Water Standard for radon in ground water is 300 pCi/L. At White King the highest radon concentrations observed in samples were collected from the mounded ground water in the protore and overburden stockpiles and ranged from 4,190 and 1,800 pCi/L, respectively. Radon activities were much greater in the shallow bedrock wells located beneath the stockpiles and ranged from a maximum of 21,300 pCi/L at the protore stockpile to a maximum of 678 pCi/L at the overburden stockpile. Activities upgradient and downgradient of the stockpiles were lower and ranged from 441 to 551 pCi/L indicating this level of radon is naturally present in the aquifer. At Lucky Lass shallow downgradient wells had radon activities ranging from 283 to 556 pCi/L.

5.3.2 Fate and Transport

As part of the RI, geochemical speciation modeling was performed to determine metal species most likely present in ground water and to evaluate potential changes in speciation with ground water transport. The modeling, which applied site-specific conditions, indicated that constituent movement through the ground water is slow. Many of the constituent species exist in relatively insoluble forms and there is evidence of significant attenuation with the subsurface materials. In the case of uranium, the results indicate that it is strongly adsorbed by aquifer material and is removed from ground water as it migrates downgradient. The general trend observed for arsenic mirrors that of uranium with higher concentrations of arsenic detected within the White King stockpiles and rapid attenuation beneath and downgradient of the stockpiles. Results of the sampling efforts confirm the geochemical modeling conclusions. Other conclusions from the modeling indicate that there is no co-located low pH acidic ground water at the Mines site indicating that either neutralization or acid buffering is occurring in the ground water. In addition, no corresponding radionuclide or inorganic plumes (as illustrated by uranium-238 activity and arsenic concentrations) were detected suggesting that metals are strongly adsorbed or retarded by aquifer solids.

Other transport pathways are movement of solid mineral matter from the high wall above the White King pond and from the stockpiles via erosion and surface water transport of suspended particulates. Any material which is eroded in the area of the high wall would be deposited in the sediment at the bottom of the White King pond. Erosion and surface water runoff from the stockpiles during storm events may transport suspended solids containing metals of concern downgradient. Arsenic and uranium have been the only COCs detected with any regularity in Augur Creek downgradient of the Mines site.

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SECTION 6

CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

This section discusses the current and reasonably anticipated future land uses and current and potential beneficial ground water uses at the Mines site, and discusses the basis for future use assumptions. This information forms the basis for reasonable exposure assessment assumptions and risk characterization conclusions in Section 7.

6.1 LAND USES

The Mines site and surrounding area is currently uninhabited. A Forest Service key is required to gain vehicle access to the Mines site. The nearest city is Lakeview, located 17 miles to the southeast. Lakeview has a population of 2,785 and is the county seat and urban center of Lake County. The closest permanent residents to the Mines site live near the intersection of FS3780 and County Road 16B, approximately 12 miles southeast of the Mines site. Primitive campsites exist in Fremont National Forest in the general vicinity of the Mines site, with many used as hunting camps in the fall. Wood cutting and cattle grazing also occur in the general area of the Mines site.

Figure 6-1 shows the property boundaries of private and public land ownership at the White King Mine area. Lucky Lass Mine is located entirely on National Forest System lands. The boundaries of the privately-owned property are:

> Parcel 1, S1/2NE1/4, Section 30, T.37S., R.19E., W.M. This parcel is currently owned by the Coppin Trust (surface estate) and members of the Leehmann and Coppin families (mineral estate)
>
> Parcel 2, NW1/4SW1/4, Section 29 and NE1/4SE1/4, Section 30, T.37S., R.19E., W.M. This parcel is currently owned by Fremont Lumber Company (surface estate) and members of the Leehmann and Coppin families (mineral estate)

The intended future use of the Mines site and the immediate vicinity is for commercial production of timber and forage for domestic livestock as described in the current Forest Management Plan. Future on-site human receptors might include timber workers, USFS personnel, recreational users, and trespassers.

6.2 GROUND AND SURFACE WATER USES

The ground water associated with the Mines site is not currently used, nor will it likely be used for any purpose in the future due to the remote location of the Mines site and the limited quantity and quality of water in the shallower zones. The reasonable likely future use of ground water in the vicinity of the Mines site is for discharge to surface water. Surface water in this area is currently used by livestock and wildlife.

Water quality in the White King pond, Lucky Lass pond, and Augur Creek are required to meet the standards and beneficial uses under OAR 340-41 for the Goose Lake basin. The potential beneficial use for these areas is for aquatic life, livestock, and recreation. The remedy also incorporates the objective of protecting the reasonable likely future beneficial uses as defined under ORS 465.315 and the corresponding rule OAR 340-122-090 and -115. At the White King pond the potential future beneficial use is for aquatic life. Livestock watering and recreation are also reasonably likely, but will be restricted as part of the remedy.

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SECTION 7

SUMMARY OF SITE RISKS

Human health and ecological risk assessments were conducted to evaluate the potential for current and future impacts of Site-related contaminants on receptors inhabiting or visiting the White King/Lucky Lass Mines site. These evaluations are discussed in detail in Volume V of the RI/FS which is located in the Administrative Record for the Mines site. The baseline risk assessment estimates what risks the Mines site poses if no action was taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the baseline risk assessment for the Mines site.

7.1 HUMAN HEALTH RISK ASSESSMENT

7.1.1 Identification of Chemicals of Concern

Contaminants evaluated in the human health risk assessment include those chemicals that exceeded background levels representative of unmineralized areas, exceeded EPA risk-based screening concentrations (Region III risk based screening concentrations dated October 4, 1995), and were not "essential nutrients" for humans. Based on this evaluation, chemicals of potential concern (COPCs) identified for human and ecological receptors include inorganic constituents and certain uranium and thorium series radionuclides. Based on the findings of the human health risk assessment this list was narrowed down to Arsenic and Radium-226 as the primary chemicals of concern (COC).

7.1.2 Conceptual Site Model

The media, exposure pathways, and receptors considered in the risk assessment are identified in the human health conceptual model presented in **Figure 5-1**. The receptors chosen for evaluation are based on knowledge of current and projected future use scenarios for the Mines site. The media chosen for consideration are those potentially impacted by historical mining activities for which there is a potential for human exposure. Some of the pathways were excluded from quantitative evaluation based on qualitative and/or quantitative reasoning. A description of the receptors chosen for evaluation is presented below in Section 7.1.3.

7.1.3 Exposure Assessment

The objectives of the exposure assessment are to identify potential exposure scenarios by which contaminants of concern in Mines site media could contact humans and to quantify the intensity and extent of that exposure.

The intended future use of the Mines site and the immediate vicinity is for commercial production of timber, recreation, and forage for domestic livestock. Future on-site human receptors might include timber workers, USFS personnel, recreational users, and trespassers. There is no current residential use at the Mines site and the likelihood that the area would be used for residential use in the near future is small given the current land ownership and remote location of the Mines site.

However, because of the long-lived radionuclides (decay rate from days to 1000s of years) at the Mines site, the baseline risk assessment evaluated potential risk under a residential use scenario which includes workers, recreational users (also used to represent potential exposure to a trespasser), and residents. A complete summary of all the scenarios and pathways considered in the risk assessment are set forth in the baseline risk assessment report which is located in the Administrative Record for the Mines site.

7.1.3.1 Receptors Evaluated in the Risk Assessment

Site Worker

A worker would potentially be exposed to site-related COCs through contact with surface and subsurface stockpile material, surface and subsurface soil, surface water and sediment in Augur Creek, ponded water and sediment in the mine pits, and airborne dust and vapors. It is assumed that exposure to subsurface soil could occur in the future if workers engaged in intrusive activities.

Although listed as possible routes of exposure, exposure pathways for mine pit water and sediment were not evaluated. It was assumed that a worker would be aware of the contamination at the Mines site through a Site safety and health plan and would not drink the mine pit water.

Recreational User

The recreational land user includes adults and children who spend a limited amount of time at or near the Mines site fishing, swimming, hunting, or engaging in other recreational activities. A recreational user could potentially be exposed to COCs through contact with stockpile material, surface soil, airborne dust and vapors, Augur Creek surface water and sediment, and mine pit ponded water and sediments. A recreational user may contact subsurface soil in the future if the activities of other receptors (i.e., workers or residents) resulted in the transport of subsurface soil to the surface. In addition, a recreational user may be exposed to site-related contamination from ingestion of game or fish caught on the Mines site.

Resident

A future resident could potentially be exposed to site-related COCs through contact with surface and subsurface stockpile materials, surface and subsurface soil, airborne dust and vapors, and ground water. Although ground water associated with the Mines site is not currently used as a source of potable water, it was considered a possible medium of exposure for potential future residents. In addition to these media, a resident may be exposed through ingestion of home-grown produce, ingestion of home-raised livestock, contact with Augur Creek surface water and sediment, and contact with mine pit ponded water and sediment.

7.1.3.2 Exposure Pathways Excluded From Quantitative Evaluation

Based on semi-quantitative and/or qualitative reasoning, certain exposure pathways were excluded from quantitative evaluation in the risk assessment A brief discussion of the reasons for the elimination of these pathways is presented below.

Inhalation of Gas (Radon) in Outdoor Air

In the screening process used to identify COPCs for the Mines site, it was determined that radon gas in the air was present at concentrations equivalent to background [See the Technical Memorandum: Constituents of Potential Concern]. For this reason, this constituent (and consequently this pathway) was eliminated from consideration.

Dermal Contact with Stockpile Materials, Soil, and Sediment

As indicated in the conceptual site model and risk assessment report, exposure via dermal contact with stockpile material and soil was not evaluated. As discussed in the *Dermal Exposure Assessment: Principles and Applications* (EPA, 1992b - the released guidance at the time of the risk assessment), there are only nine chemicals for which percutaneous absorption from a soil matrix has been studied: eight organic chemicals and cadmium. None of these eight organic chemicals were COPCs at the Mines site and cadmium was not included as a COPC. Therefore dermal contact with stockpile materials, soil, and sediment was not quantitatively evaluated.

Dermal Contact with Surface Water

As with dermal contact with stockpile materials, soil, and sediment, dermal contact with Augur Creek surface water and mine pit water was not evaluated due to a lack of available information on the percutaneous absorption of the COPCs. In addition review of EPA's *Dermal Exposure Assessment: Principle and Applications* (EPA, 1992b) revealed that permeability coefficient for the COPCs identified for water were not available at the time.

In addition, this guidance states that the solubility of a compound (either in a lipid or aqueous solution) is a primary factor governing its dermal permeability. At the Mines site, the COPCs identified for surface water are all inorganic compounds which are most likely in the form of an insoluble metal or an inorganic salt which are in the group of compounds least able to penetrate the skin. Therefore, in addition to the lack of available chemical-specific information, dermal absorption of the COPCs in water was not evaluated due to their limited ability to penetrate the skin.

External Radiation from Surface Water

Based on professional judgement, it was assumed that the radiation exposure an individual would receive from being in contact with or in close proximity to surface water would be negligible compared to the radiation exposure received from ingesting surface water. Once surface water is ingested, the radiation remains until metabolic processes eliminated the contaminant, or until the radionuclide completes its decay series. Conversely, external radiation associated with being near surface water would end the moment a person left the water body. For this reason, external radiation from surface water (i.e., Augur Creek surface water and mine pit water) was not quantitatively evaluated.

Ingestion of Homegrown Produce

EPA Region 10 Supplemental Risk Assessment guidance for Superfund (EPA, 1996a) states that the site characteristics which would make consideration of food chain pathways (such as produce ingestion) important are current residential use of the site, the presence of large areas of contaminated soil in an agricultural area, and the presence of contaminants known to be taken up into plants at potentially significant levels (e.g., cadmium and PCBs). None of these factors apply to conditions present at the Mine site, which provides support for the decision to exclude this pathway from evaluation.

Ingestion of Livestock and Game

In order to estimate edible tissue concentrations in game/livestock it is necessary to model the following: plant concentrations from soil concentrations, animal tissue concentrations based on plant ingestion, animal tissue concentrations based on incidental soil ingestion while grazing, and animal tissue concentrations based on ingestion of surface water. There is limited information available to quantify these exposure pathways and studies that are available indicate that metal uptake into edible tissues is not a concem. These factors in combination with the limited amount of time an animal would graze in the vicinity of the Mines site provide the basis for exclusion of this pathway from evaluation.

Ingestion of Fish

During the RI, the only fish seen in Augur Creek in the vicinity of the Mines site were brook lampreys, which are not consumed by humans. Downstream of the Mines site, Augur Creek sustains a 400-foot drop over a distance of less than 0.6 miles. The steepness of the creek bed prevents trout or other species found in the lower stretches of Augur Creek from migrating to areas of the creek adjacent to the Mines site. Ingestion of fish was not quantitatively evaluated in the risk assessment due to the absence of edible fish in Augur Creek in the vicinity of the Mines site, and because physical conditions of the creek restrict new species.

During the Feasibility Study (FS), EPA requested Kerr McGee evaluate human health effects that may be associated with ingestion of fish containing inorganic arsenic in White King pond if the pond is to be used in the future as a sport fishing resource. Based on their report, Kerr McGee concluded that the fish in the White King Pond would not contain levels of inorganic arsenic that would pose a health concem. This conclusion is based on a number of factors, including: low potential for inorganic arsenic to bioconcentrate in freshwater finfish, metabolic processes that detoxify inorganic arsenic in fish, data from other sites showing low potential for inorganic arsenic to pose a risk, and a preliminary risk evaluation using the White King Pond water concentrations.

7.1.4 Exposure Point Concentrations

Exposure point concentrations were defined by identifying geographical areas that could be contacted by the receptors of concem. Five general geographic areas were defined for the Mines site. These areas are the following:

- The protore stockpile at the White King Mine
- The overburden stockpile at the White King Mine
- Off-pile areas at the White King Mine
- The overburden stockpile a the Lucky Lass Mine
- Off-pile areas at the Lucky Lass Mine

Exposure point concentrations were calculated for a potential future resident, current and future Forest Service workers, and current and future recreational users. A current resident was not considered because there are currently no residents at the Mines site. Current and future exposure point concentrations were assumed to be the same for all media except soil. For soil, current exposure point concentrations were calculated incorporating soil analytical results from a depth of 0-6 inches; future exposure point concentrations were calculated incorporating soil analytical results from a depth of 0 to 6 feet (EPA, 1992c). Exposure point concentrations for the receptors of concern were calculated for soil, air, surface water, sediment, and ground water. A summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations are presented in **Tables 7-1 to 7-7.**

The summary of the exposure parameter values (e.g. exposure frequency (days/year), exposure duration (years) for the reasonable maximum exposure are presented in **Table 7-8**.

7.1.5 Toxicity Assessment

The human health toxicity assessment quantified the relationship between estimated exposure (dose) to a contaminant of concern and the increased likelihood of adverse effects. Risks of contracting cancer due to a site exposure are evaluated based on toxicity factors (cancer slope factors or CSFs) published by EPA. Quantification of non-cancer injuries relies on published reference doses (RfDs).

CSFs are used to estimate the probability that a person would develop cancer given exposure to site-specific contaminants. This site-specific risk is in addition to the risk of developing cancer due to other causes over a lifetime. Consequently, the risk estimates generated in risk assessment are frequently referred to as "incremental" or "excess lifetime" cancer risks.

RfDs represent a daily contaminant intake below which no adverse human health effects are expected to occur. To evaluate noncarcinogenic health effects, the human health impact of contaminants is approximated using a hazard quotient (HQ). Hazard quotients are calculated by comparing the estimates to site-specific human exposure doses with RfDs. Values greater than 1.0 are considered to represent a potential risk.

The following hierarchical approach was used to determine toxicity values:

The Integrated Risk Information System (IRIS) computer database (EPA, 1996b)

The Health Effects Assessment Summary Tables (HEAST) (EPA, 1995b)

EPA Region 10 was consulted for toxicity values when toxicity values were not available from the above sources.

With the exception of lead (there are currently no EPA-derived slope factors for lead), all COPCs evaluated in the assessment that have evidence of carcinogenicity in animals or humans and are classified as carcinogens by EPA (Groups A, B, or C) were evaluated for potential carcinogenic risk. Certain inorganic COPCs (cadmium, chromium VI, and nickel) are only considered carcinogenic through the inhalation route. Therefore, cancer risk through oral ingestion exposure routes was not evaluated for these COPCs.

7.1.6 Risk Characterization

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. This "excess lifetime cancer risk" is calculated from the following equation:

Risk = CDI x SF

where: risk = a unitless probability (e.g., 2 x 10^{-5} or 2E-5) of an individuals's developing cancer

CDI = chronic daily intake averaged over 70 years (mg/kg-day)

SF = slope factor, expressed as (mg/kg-day)-1

(See **Table 7-8** for a summary of the input parameters used in the risk calculations)

Risks are probabilities that usually are expressed in scientific notation (*e.g.*, 1 x 10^{-6} or 1E-6). An excess lifetime cancer risk of 1 x 10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing cancer from all other causes has been estimated to be as high as one in three. EPA's generally accepted risk range for site-related exposures is 1 x 10^{-4} to 1 x 10^{-6}. Oregon cleanup rules defined at OAR 340-122-115 establish acceptable risk for carcinogens at or below 1 x 10^{-6} for individual carcinogens and 1 x 10^{-5} for cumulative carcinogens.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (*e.g.*, life-time) with the RfD derived for a similar exposure period. An RfD represents a level that an individual may be exposed to a given chemical that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ < 1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all chemical(s) of concem that affect the same target organ (*e.g.*, liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. A HI < 1 indicates that, based on the sum of all HQ's from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI > 1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-Cancer HQ = CDI/RfD

where: CDI=Chronic daily intake

RfD = reference dose

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

7.1.6.1 Cancer Risk Summary

A summary of the Mines site cancer risks for each scenario/receptor is presented in **Tables 7-11 to 7-18.** The results of the human health risk characterization indicated that the following exposure scenarios had elevated risks:

A White King Mine current adult worker had a total risk of 6 x 10^{-5} due to ingestion of arsenic in soil and exposure to external radiation from radium-226/228 in soil. In a future scenario the risk to workers were slightly greater with a total risk of 2 x 10^{-4}. These risks were also associated with ingestion of arsenic in soil and exposure to radiation from radium-226 in soil.

For the future recreational user (child) at the White King Mine total cancer risks were 4 x 10^{-4}. This is due to exposure to arsenic in soil, exposure to external radiation from radium-226/228 in soil, and ingestion of arsenic in Augur creek and White King pond sediment and surface water. These risks are primarily associated with incidental ingestion of arsenic in surface soils (3.9 x 10^{-4}). Total risks to the current recreational user (child) were slightly lower at 2 x 10^{-4}.

For the potential future resident (adult) at the White King mine, the total chemical and radionuclide cancer risks were 3 x 10^{-1}. The chemical and radionuclide cancer risks are associated with ingestion of arsenic in soil (5 x 10^{-2}) and exposure to external radiation from radium-226/228 (5 x 10^{-2}), ingestion of arsenic in shallow bedrock ground water[4] (3 x 10^{-1}), inhalation of radon in shallow ground water (1 x 10^{-2}), and exposure to arsenic in White King Pond surface water and sediment (10 x 10^{-6}). The total risks to the future child resident were 2 x 10^{-1} from the same exposure points and chemicals of concern.

For the potential future resident at the Lucky Lass mine, the total chemical and radionuclide cancer risks were 1 x 10^{-3}. The highest chemical cancer risks are associated with ingestion of arsenic in shallow ground water (6 x 10^{-4}), inhalation of radon from shallow ground water (6 x 10^{-4}), ingestion of arsenic in surface soil (2 x 10^{-6}), and exposure to external radiation from radium-226/228 in soil (2 x 10^{-4}). The total risk to the future child resident were slightly lower at 5 x 10^{-4}. from the same exposure points and chemicals of concern.

7.1.6.2 Noncancer Health Effects

A summary of the non-carcinogenic risks are shown in **Tables 7-19 to 7-24.**

The estimated hazard index for current workers was 0.4 due to exposure to arsenic in soil which is below the benchmark value of 1. The estimated hazard index for both the current and future adult

[4] Deep bedrock ground water throughout the Mines site, which is not impacted by historical mining activities, contains levels of naturally occurring arsenic, radon, and minerals that are likely to preclude its use as a residential drinking water source. Risks associated with exposure to shallow bedrock ground water at the White King protore stockpile are dominated by a single well. For a variety of reasons, use of the shallow aquifer for drinking water purposes in the vicinity of the Mines site seems unlikely. Therefore, this exposure pathway very likely overestimates the potential risks.

recreational users exposure to overburden soils throughout the Mines site were also below the benchmark value of 1.

Estimates for both current and future child recreational users (hazard index of 4 and 11 respectively) were above the hazard index of 1, indicating that there is a potential for adverse health effects. The potential for current and future adverse noncancer health effects to a child are primarily associated with incidental ingestion of arsenic in overburden soil (1×10^1 to 3×10^0).

There is a potential for adverse noncarcinogenic effects to potential future residents residing at the White King Mine with a total risk of 2×10^3. This risk is associated with ingestion of arsenic and manganese in shallow bedrock ground water (2×10^3) and ingestion of arsenic in soil (30).

There is also a potential for adverse noncarcinogenic effects to potential future resident residing at Lucky Lass Mine that is associated primarily with the ingestion of arsenic in deep bedrock ground water (4). All estimated hazard indices associated with exposure to surface water and sediment in White King pond, Lucky Lass pond, and Augur creek were below the benchmark value of 1 indicating that there is little potential for adverse noncarcinogenic effects for all receptors from these pathways.

7.1.6.3 Uncertainties

Uncertainties associated with the human health risk assessment includes exposure assumptions (e.g., pathways, frequency, and duration), the applicability of experimental animal study data on humans, potential differences in toxicity and absorption efficiency between humans and laboratory animals, derivation of dermal toxicity values from oral toxicity values, and the validity of adding risks or hazard quotients for multiple chemicals or pathways. Because several factors used in the risk assessment are uncertain, a conservative (risk aversive) approach was used to select variables for use in risk calculations.

The key uncertainties that may impact the estimate of risk for the Mines site are presented below:

Uncertainty Associated with Background Concentrations

The ability of the selected soil and sediment background locations to accurately depict area background concentrations is another source of uncertainty. Within mining areas there are often localized areas of high mineral deposits, and it is possible that the chosen background locations either missed or over represented these areas of high natural deposits. This could have the effect of eliminating COPCs through the screening process that should have been included or retaining COPCs that should have been screened out based on background. This indirectly is a source of uncertainty in the risk assessment which could lead to an underestimation or overestimation of total potential risks associated with the Mines site.

Another source of uncertainty associated with background concentrations is the absence of sufficient background characterization for shallow and deep bedrock ground water. Because the primary COCs associated with risk due to exposure to ground water (i.e., arsenic and radon) are known to be naturally occurring in the area, it is likely that the lack of adequate background screening resulted in retaining these as COPCs and using these values in the risk assessment. Inclusion of these COCs may have overestimated the risk due to ground water exposure.

Uncertainties in Analytical Data

Analytical results are variable due to the sample matrix, analytical method, and the laboratory performing the analysis. At the Mines site where a COPC was detected in a least one sample, nondetected samples were assigned estimated concentrations of one-half the detection limit. This may either over or underestimate the actual concentrations. Another uncertainty associated with the analytical data was the use of subsurface soil radionuclide concentrations to represent surface soil radionuclide concentrations. Surface soil radionuclide concentrations may be higher, lower, or similar to subsurface concentrations. Therefore risk to receptors may be underestimated, overestimated, or unaffected.

Uncertainties with Exposure Estimates

The choice of receptors evaluated in the risk assessment was based on knowledge of current site use and predictions of plausible future site use. Because current Site use (i.e., worker and recreations use) is documented, there is little uncertainty associated with the choice of these receptors. Conversely, the assumption that a resident would live at the Mines site is very uncertain and may overestimate risks.

7.2 ECOLOGICAL RISK ASSESSMENT

This section summarizes the results of the baseline ecological risk assessment for the Mines site. The objectives of the assessment were to assess qualitatively and quantitatively potential adverse effects to ecological receptors from contaminants detected at the Mines site.

The ecological risk assessment was conducted under a tiered or phased approach. The first phase (Tier I) involved conducting a screening level risk assessment where potential habitats, receptors, and exposures were identified, refined, and compared to site-specific COPC data to identify potential ecological risks. **Figure 7-1** shows the receptor and community feeding relationships and **Figure 5-2** depicts the ecological conceptual site model. The results from this assessment either identified a need for a more specific Tier II assessment or indicated that no remedial action was warranted.

Based on the findings of the Tier I assessment, a Tier II assessment was conducted to evaluate uncertainties associated with the risk estimates that were elevated in the screening ecological risk assessment for the Mines site. Specifically risk estimates that were based on terrestrial risk models or sediment guidelines were reassessed if the hazard quotient exceeded a value of 10. Risk estimates that were based on water quality criteria (ODEQ, 1994; EPA, 1986, 1992) were reassessed if the hazard quotient exceeded a value of 1.0. The following locations and media were considered in this reassessment of uncertainties: White King sediments, Lucky Lass pond sediments and surface water, and Augur Creek sediments and surface water.

7.2.1 Ecological Setting

The general vicinity of the Mines site contains a diverse assortment of habitat types as well as diverse wildlife communities (See **Figure 7-2** - Habitat Characterization Map). Vegetation associated with the Mines site can be characterized as forested and non-forested plant communities. Dominant plant communities found at the Mines site include mixed conifer forests comprised of ponderosa pine and lodgepole pine, wet-meadows, and shrub-steppe areas. Wet-meadow areas north of White King pond, south of the White King overburden pile, and north of the Lucky Lass overburden pile are dominated by sedge, meadow foxtail, Kentucky bluegrass, rushes, and tufted hairgrass. No Federally or State listed, threatened, or endangered plants have been identified within the boundaries of the Mines site.

The primary types of terrestrial mammals, amphibians and reptiles, and birds observed within the Mines site are species typically found in shrub-steppe, wet meadows, mixed conifer forested habitats in this region of southern Oregon. Both resident and migratory wildlife are present in the area. The most common mammals in the region are the least chipmunk, mule deer, pronghorn, black bear, and coyote. Birds commonly found in the region include the red-tailed hawk, northern harrier, common flicker, hairy woodpecker, common raven, green-tailed towhee, and dark-eyed junco. In addition, numerous sightings of the greater sandhill crane were made at the Mines site during field investigations.

In the aquatic environment, redband trout and pit-klamath brook lamprey utilize a portion of Augur Creek approximately 2 miles downstream from the White King Mine. However, for a number of reasons (see Section 5.2.6) they do not inhabit the portions of the creek adjacent to the Mines site. Aquatic invertebrates observed during field investigations at the White King pond include giant water bugs, aquatic worms, stoneflies, and true-fly larvae.

Species of Special Status

Federally Listed

The bald eagle, listed as threatened by the Federal Government under the Endangered Species Act of 1973, was identified as potentially utilizing areas associated with the Mines site. At the time of the risk assessment no observations of bald eagles either foraging or nesting in the study area had been documented. In 1990 and in 2001 a Biological Evaluation conducted by the Forest Service did not identify any eagles inhabiting the Mines site.

State of Oregon Listed Species

The Oregon Fish and Wildlife Commission (OFWC) also maintains a list of threatened and endangered species under OAR 635-100-125. No species on this list inhabit the Mines site. The State also maintains a list of sensitive species of vertebrates for the State of Oregon under OAR 635-100-040. The only Oregon-listed sensitive species observed at the Mines site was the greater sandhill crane, which is classified as vulnerable. Sensitive species listed as vulnerable are species that are not in imminent threat of becoming threatened or endangered and can avoid becoming listed as endangered through continued and/or expanded use of adequate protection measures and monitoring as defined by the Oregon Natural Heritage Program (ONHP, 1993).

Sensitive or Critical Habitat

Wetlands

Palustrine emergent wetlands (i.e., wet-meadows) situated on and downgradient of the Mines site were identified during field investigations. Based on field observations, these meadow areas displayed characteristics (i.e., hydrophytic vegetation, hydric soils, and hydrology) satisfying the criteria for identification of a wetland as outlined in the 1987 Corps of Engineers Wetland Delineation Manual (ACE, 1987). The exact boundaries of these wetland areas have not been delineated nor has a wetland assessment been conducted at the Mines site. The critical and unique status of wetlands and the associated flood plains downgradient of the Mines site may need to be determined prior to the commencement of any remedial action.

7.2.2 Identification of Chemicals of Concern

Similar to the human health risk assessment approach, contaminants evaluated in the ecological risk assessment included those chemicals that exceeded background. The risk-based screening step was not conducted for ecological receptors; therefore, all constituents that were determined to be present above background concentrations were included as COPCs for the ecological risk assessment.

Based on the findings of the ecological risk assessment this list was narrowed down to the following COCs as shown in **Tables 7-25 to 7-28:**

White King Pond Surface Water

- Aluminum
- Arsenic

Auger Creek and White King Pond Sediment

- Arsenic
- Manganese
- Mercury

White King and Lucky Lass Soil

- Arsenic
- Antimony
- Mercury
- Selenium

7.2.3 Exposure Assessment

As previously stated, screening was performed before the ecological risk assessment. Therefore, the receptors and exposure pathways were initially identified on a broad trophic-level scale (**Table 7-29** summarizes the ecological exposure pathways of concern). Identifying receptors at the Mines site involves identifying primary routes of exposure through an understanding of the potential migration of COPCs (i.e., fate and transport). How groups of receptors are likely to be exposed and which media are likely to be involved in the primary routes of exposure was determined by identifying potential migration of COPCs.

7.2.4 Identification of Receptors

Individual receptor species, as defined by their trophic level (e.g., decomposer, producer, primary consumer) and group (e.g., plants, birds, mammals), were selected to represent all exposed receptors with comparable habitat requirements, feeding preferences, and life histories, as well as critical or "key" species identified by the following characteristics:

- Receptors that are vital to the structure and function of the food web such as principle prey or primary food sources of principle prey.
- Receptors that exhibit increased sensitivities to the COPCs.
- Receptors that have unique life histories or feeding behaviors whose loss may result in the elimination of a unique ecological niche or unpredictable results on the overall ecosystem.

An effort was made to select receptor species that most closely reflect these "critical" characteristics as well as species that are expected to inhabit the Mines site. Two bird species and one mammal species were selected as potential receptors for the Mines site because of their ability to feed and nest in areas of affected soil, sediment, and/or surface water. A plant and seed-eating bird (i.e., herbivore/granivore), represented by the blue grouse (*Dendragapus obscurus*), and an invertebrate-eating mammal (i.e., carnivore), represented by the vagrant shrew (*Sorer vagrans*), were selected to assess potential ecological impact from COPCs in White King and Lucky Lass mining area soil. The blue grouse was chosen as a receptor that is expected to be representative of other species of herbivorous/granivorous birds occupying a similar habitat at the Mines site. Similarly, the vagrant shrew was chosen as a receptor that is expected to be representative of other carnivorous species of small mammals occupying similar habitat at the Mines site. An Oregon-listed sensitive species of bird, the greater sandhill crane (*Grus canadensis tabida*), which feeds on aquatic organisms, was selected to assess potential ecological impact from COPCs in White King and Lucky Lass Mine pit water and sediment and Augur Creek surface water and sediment. The greater sandhill crane was chosen as a receptor that is expected to be representative of species of fish-eating birds occupying similar habitat at the Mines site.

Plants, aquatic invertebrates, and aquatic biota (including herpetiles and fishes) were also selected as receptors based on the potential for transport of COPCs to the soil, ponds, and creek associated with the Mines site. Plants were selected as receptors because of their close association with soil. Exposure of plants to COPCs in soil is expected through direct contact and uptake as the primary exposure routes. Aquatic invertebrates were selected as receptors because of their close association with benthic (i.e., sediment) environments. Aquatic biota were selected as receptors because of the close association of this community with surface water and wetland environments.

The incidental ingestion of COPCs in soil or sediment and the indirect ingestion of COPCs through dietary intake were selected as the primary routes of exposure for the receptor species (i.e., blue grouse, vagrant shrew, and sandhill crane). The primary exposure routes for aquatic invertebrates are diet and incidental ingestion and dermal contact with sediment. The primary exposure routes for aquatic biota to COPCs in surface water are diet and ingestion and dermal contact with surface water.

Exposure to COPCs in surface and subsurface soil at White King and Lucky Lass Mines was assessed by evaluating direct contact and uptake by plants, and ingestion of food (i.e., plants and soil invertebrates) and soil by the blue grouse and vagrant shrew. Exposure to COPCs in sediment from the White King Mine pond, Lucky Lass Mine pond, and Augur Creek was assessed by evaluating ingestion and dermal contact by aquatic invertebrates, and ingestion of aquatic organisms and sediment by the sandhill crane. Similarly, exposure to COPCs in surface water of White King and Lucky Lass ponds and Augur Creek was assessed by evaluating ingestion and dermal contact by aquatic biota, ingestion of aquatic organisms by the sandhill crane, and ingestion of surface water by the blue grouse, vagrant shrew, and sandhill crane. This simplified approach incorporated the conservatism needed to encompass all potential ecological effects that may be occurring at the Mines site.

7.2.5 Exposure Point Concentrations

Exposure point concentrations were derived for sediment, surface water, and soil and are presented in **Tables 7-25 to 7-28.** Maximum values were used as exposure point concentrations for all media at the Mines site. To estimate the environmental receptors exposure to radionuclides the absorbed doses (in Gy/day) were calculated for each receptor following the methodology described in *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards* (IAEA, 1992). Radionuclide-specific factors were based on those for radium-226 (Ra-226) as well as uranium-238 (U-238).

7.2.6 Ecological Effects Assessment

The focus of the effects assessment was to identify appropriate radionuclide and non-radionuclide effect doses for bird and mammal receptors and to identify available radionuclide effect doses and non-radionuclide effect criteria for communities of terrestrial plants, aquatic invertebrates, and aquatic biota. Defining the ecological effects (i.e., eco-toxicity) that may be associated with the receptors and the COPCs at the Mines site involved establishing potential effect doses from current literature and selecting effect criteria from appropriate regulatory guidance and literature sources.

Radionuclide effect doses were selected for birds, mammals, terrestrial plants, aquatic invertebrates, and aquatic biota from list of studies summarized in Eisler, 1994. Non-radionuclide effect doses for species of birds and mammals were obtained from peer reviewed primary research articles. Primary factors considered in the selection of suitable studies include study species, study duration, effect dose, and effect endpoint. Aquatic invertebrate effect criteria for non-radionuclides COPCs were obtained from the Ontario Ministry of the Environment (OME) *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario* (Persaud et al., 1993). Aquatic biota effect criteria for non-radionuclide COPCs were obtained from the Oregon State-Wide Water Quality Management Plan; Beneficial Uses, Policies, Standards and Treatment Criteria (ODEQ, 1994). At the time of the RI/FS the Oregon State-Wide Water Quality Management Plan had adopted EPA Ambient Water Quality Criteria (AWQC) [EPA, 1992] for regulating freshwater within the State of Oregon (ODEQ, 1994). The AWQC have been updated periodically. At the time of this ROD, the most recent version was published in December 10, 1998 with two corrections issued in April 1999.

7.2.7 Risk Characterization

The results of the ecological risk assessment are summarized in **Table 7-29.** The assessment showed some adverse impact, based on screening level assessment only, for the blue grouse, vagrant shrew, and terrestrial plants exposed to non-radionuclides (hazard index ranging from 38 to

94,000[5]) primarily from arsenic, selenium, antimony, lead, and mercury in surface and subsurface soil at the White King Mine. At Lucky Lass only slightly elevated risks (hazard index ranging from 1 to 3) were predicted for the vagrant shrew and terrestrial plants exposed to arsenic and silver in surface soil.

The risk assessment also predicted adverse impact, based on screening level assessment only, for aquatic invertebrates exposed to non-radionuclide COPCs in the sediments of the White King pond, Lucky Lass pond, and Augur Creek. The greatest risks were associated with arsenic in sediments at White King (HI of 33) and Augur Creek (HI of 27). There were additional elevated risks to aquatic invertebrates from manganese in Augur Creek (HI of 13). Adverse impact was also predicted for the sandhill crane exposed to non-radionuclide COPCs in White King pond and Lucky Lass pond sediment, but these impacts may also occur at levels below background concentrations.

A Tier 2 analysis was conducted to reassess in further detail the uncertainties associated with the risk estimates that were elevated in the screening ecological risk assessment for the Mines site. This reassessment of uncertainties indicated that no adverse impact is predicted for the sandhill crane due primarily to the highly conservative Biota-sediment accumulation factors (BSAF) used to estimate fish tissue concentrations in the screening level assessment. In addition, no adverse impacts to aquatic biota are expected in the Lucky Lass pond and Augur Creek surface water, since dissolved concentrations do not exceed water quality standards.

Since the bio-availability of arsenic and manganese affects whether benthic organisms will be impacted by these metals, further evaluation of the bioavailability of these metals in White King pond sediment (arsenic only) and Augur Creek sediment (arsenic and manganese) may be warranted.

There were no adverse impacts to ecological receptors predicted for the radionuclide and nonradionuclide COPCs in water of the White King pond, Lucky Lass pond, or Augur Creek. Little aquatic life has been observed to inhabit White King pond, and is presumed to be due to historically low pH water prior to pond neutralization in 1998. EPA established PRGs for aluminum and pH for White King pond surface water.

7.2.8 Uncertainties

Significant uncertainties in the screening level ecological risk assessment can be found with chemistry and sampling analysis, fate and transport parameters, exposure assumptions, and toxicological data. The largest sources of uncertainty are found in the use of very conservative exposure assumptions and the use of potentially weak toxicological data from laboratory studies rather than site-specific toxicity data.

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[5] Numerically large hazard quotients are associated with exposure to lead at the Mines site. Lead was detected at a maximum concentration of 515 mg/kg and an average of 28 mg/kg for all soil samples collected at the Mines site. The average value is very similar to the background lead levels that ranged from 11.3 to 16.7 mg/kg. The ecological assessment assumes all receptors are continuously exposed to the maximum detected concentration of lead (and all other COPCs) so these values may overestimate the true risk to ecological receptors.

7.2.8.1 Environmental Chemistry and Sample Analysis

As previously stated maximum values were used as exposure point concentrations for all metals at the Mines site. This is likely to result in overestimation of risk to receptors who may inhabit a greater area than the area represented by just one or a few samples.

COPCs in White King pond and Lucky Lass pond sediment and surface water were not completely evaluated in the background screening process because of lack of background data at the pond. This is likely to result in an overestimation of risk since constituents with a least one detected value were evaluated as COCs instead of only those constituents that were significantly above background levels. This is especially important since the pond bottoms represent naturally mineralized zones. The potential for overestimation of risk for naturally occurring elements is also true for aluminum, calcium, magnesium, potassium and sodium, which are primary soil components and, with the exception of aluminum, are considered to be essential elements.

7.2.8.2 Fate and Transport Parameters

The bioavailability of COPCs in the environmental media and diet of the receptors was estimated at 100 percent. This is likely to overestimate risk since constituents in the environment are quite frequently bound as complexes that reduce their bioavailability.

Bioaccumulation was assumed to be 100 percent in the absence of site-specific bioaccumulation data. This results in an overestimation of risk for those constituents that are not expected to bioaccumulate but may result in underestimation of risk for those COPCs that have the potential to bioaccumulate in plant and animal tissues above 100 percent. Bioaccumulation factors of 0.04 for arsenic, 0.045 for lead, and 0.025 for selenium have been reported in the literature. Thus risks to a blue grouse at the Mines site may be overestimated for these metals by more than an order of magnitude. Risk to the vagrant shrew and sandhill crane may also be overestimated based on bioaccumulation of COPCs in their prey (earthworms and fish respectively),

7.2.8.3 Exposure Assumptions

Exposure parameters for all receptors were selected based on literature information and professional judgement. In addition, the amount of time spent exposed to site-related media is assumed to be the highest possible value. The conservative assumptions used are likely to overestimate the potential risk estimates

The inhalation of radon gas by active and dormant near-surface wildlife, such as the vagrant shrew, presents a potential exposure pathway that was not evaluated during this assessment. Although subsurface exposure to radon gas at the Mines site may or may not be greater than that of ambient air, exclusion of this pathway from the assessment may underestimate the potential for risk from this contaminant.

Food and water ingestion rates for all bird and mammal receptors were based on allometric models from the scientific literature. These models generally result in an overestimation of actual intake rates for ecological receptors.

For all radionuclide COPCs, exposure was estimated using human toxicokinetic data and associated dose conversion factors. Applying human toxicokinetic data to predict radionuclide fate in animals is another source of uncertainty. The effect of this uncertainty cannot be quantified.

For the radionuclide COPCs, exposure was estimated using exposure parameters specific to radium-226 (for radium isotopes) and uranium-238 (for uranium isotopes.) This adds uncertainty in calculating total radionuclide exposures, particularly for thorium, although it is unclear if potential risks are over or underestimated.

7.2.8.4 Toxicological Data

Both radionuclide and non-radionuclides effects data were obtained from literature sources that were not specific to the receptors at the Mines site. This could lead to uncertainty in estimation of risks.

Radionuclide effects data presented as acute or chronic effects values were not extrapolated to acute or chronic no-effects values. For non-radionuclide effects data, a factor of 5 was used to extrapolate from effects levels to non-effects levels. Thus, no-effected data may be underestimated by about an order of magnitude.

Avian effects data were unavailable for several non-radionuclide COPCs (i.e, antimony, barium, beryllium, and potassium), which results in uncertainty as to whether these COCs contribute to the overall risk to receptors.

The majority of available non-radionuclide effects data were determined using laboratory animals studies under laboratory conditions. These data as well as toxicological interpretations based on blood biochemistry or body weight changes may not represent adverse health effects or cannot be precisely extrapolated to a free-ranging wildlife population.

Suitable phytotoxicity (toxicity to plant) data was very limited. In instances where data were available, the lowest reported concentration of a COPC that elicited an adverse effects was selected as the effective criterion.

7.3 BASIS FOR RESPONSE ACTION

Contaminated soil stockpiles at the Mines site represent a threat to ecological and human receptors. The chance of an individual developing cancer or non-carcinogenic effects related to exposure to Site stockpiles exceed the acceptable risk range identified in the NCP and DEQ acceptable limits. Terrestrial and aquatic ecological receptors may also be harmed by exposure to surface soils, surface water, sediments, and stockpile soil.

The response action selected in the this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

7.4 REFERENCES FOR SECTION 7

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SECTION 8

REMEDIATION OBJECTIVES

Remedial action objectives (RAOs) consist of medium-specific or location-specific goals for protecting human health and the environment. This section presents the RAOs for soil, surface water, sediment, and ground water at the Mine site. It outlines the risks identified in Section 7 and provides the basis for evaluating the cleanup options presented in Section 9. Additionally, a description of the major applicable or relevant and appropriate requirements (ARARs) for components of the remedial alternatives is provided.

8.1 NEED FOR REMEDIAL ACTION

The uranium mining operations at the Mines site have resulted in widespread distribution of contaminated soils and waste rock at the White King and Lucky Lass Mines, contaminated water and sediments in the White King Pond, and contaminated sediments in Augur Creek. Key COCs at the Mines site identified in the human health and ecological risk assessment include radium-226 and arsenic. The cleanup goals were driven by either background, or ARARs, in particular the Oregon Environmental Cleanup regulations. Normally, under the NCP, EPA strives to achieve an excess human health cancer risk, for the current or reasonably anticipated future land use, of between 1×10^{-4} and 1×10^{-6}. The Oregon Cleanup regulations, which are ARARs for the selection of response actions, require that the excess cancer risk be no greater than 1×10^{-6} for each individual carcinogen, and therefore are more stringent than the NCP. The following sections outline the remediation objective for each area of the Mines site. Specific cleanup goals are discussed in Section 12.6.

8.2 REMEDIAL ACTION OBJECTIVES

8.2.1 White King Mine

At the White King Mine, the potential cancer risks to workers, recreational users, and potential future residents exceeded 1×10^{-6} from exposure to external radiation, ingestion of arsenic in soils and ingestion of contaminants in pond water, pond sediment, shallow bedrock and perched ground water. Non-carcinogenic potential risks were also elevated above 1 for the current and future recreational user and potential future resident. These risks are associated with the incidental ingestion of arsenic in overburden soil and ingestion of arsenic in pond water and sediment and arsenic and manganese in shallow bedrock and perched ground water directly beneath the stockpiles.

Ecological risks were elevated above 1 for plants and animals exposed to surface and subsurface soils These risks are primarily associated with exposure to arsenic, selenium, antimony, lead, and mercury in soils. Ecological risks were also elevated for aquatic invertebrates exposed to pond sediments. These risks are primarily associated with arsenic. .

8.2.1.1 White King Soils

The RAOs for the White King soils under current and future use scenarios are as follows:

- Reduce exposure to stockpiles and contaminated off-pile soil by humans (ingestion and external exposure) and ecological receptors (ingestion). Demonstrate protectiveness to an excess risk level of 1×10^{-6} for carcinogenic risk (or a non-cancer HQ of 1) based on reasonable maximum exposure for an individual, or background concentration whichever is higher.
- Reduce and eliminate the release and migration of contaminants from soils to ground water or surface water via erosion, oxidation, or leaching to protect for beneficial uses (recreational, agricultural, and aquatic habitat).
- Prevent the removal or use of stockpile soils for any purpose.

8.2.1.2 White King Pond

The Human Health Risk Assessment for the White King pond concluded that the pond posed a slight carcinogenic risk to current and future recreational users and potential future residents from ingestion of arsenic in surface water (4×10^{-6}) and sediment (1×10^{-5}). Based upon a limited number of samples the ecological risk assessment predicted potential risks to aquatic invertebrates exposed to non-radionuclide contaminants in the sediment at the White King pond. The greatest risks were associated with arsenic and manganese in sediments. Additionally, limited aquatic life has been observed to inhabit White King pond presumably due to historical low pH and dissolved concentrations of metals. The reasonable likely future beneficial use as defined under ORS 465.315 is expected to be an aquatic habitat. Potential livestock watering and recreation are also reasonably likely, but can be restricted as part of the remedy. The remedial action goals are as follows:

- Protect the potential beneficial use(s) (aquatic life) of the White King pond from exposure to COCs above applicable standards (Oregon's State water quality standards (OAR 340-41-925), or background concentrations (if background concentrations are higher than the applicable standard).
- Maintain a neutral pH in the White King pond water in order to reduce the toxicity of the acidic water and lower the concentrations of dissolved metals in the water.

8.2.1.3 Augur Creek

The risk assessment predicted potential adverse impact to aquatic invertebrates exposed to non-radionuclide contaminants in the sediments of Augur Creek. The greatest risks were associated with arsenic with a hazard index of 26.5. There were additional elevated risks to aquatic invertebrates from manganese in Augur Creek (HI of 13.2). There was also a slightly elevated carcinogenic risk to current and future recreational users from exposure to arsenic in Augur Creek sediment and surface water (9×10^{-6}). No adverse impact was predicted for surface water since dissolved concentrations did not exceed Federal ambient water quality standards. The RAOs for Augur Creek are:

- Reduce exposure to aquatic invertebrates and recreational users from COC's in Augur Creek surface water and sediments above protective risk-based levels for recreational users, applicable standards (Oregon's State water quality standards (OAR 340-41-925), or background concentrations (if background concentrations are higher than the applicable standard or protective level).

- Monitor surface water to ensure that the potential beneficial uses of surface water (discussed in the next section) are maintained and/or to establish a trend toward background concentrations.

8.2.1.4 White King Mine Ground water

Although future human use of ground water was determined to be unlikely, the risk assessment included human exposure to ground water. It indicated theoretical cancer risks exceeding 10^{-4} and non-cancer HQ exceeding 1 for future residential use of ground water for the bedrock aquifer. The primary risk drivers were arsenic and radon. For the shallow aquifer, the risk drivers are arsenic and radon (and beryllium and manganese at one location) directly below the protore and overburden stockpiles. The concentrations of arsenic in all of the downgradient monitoring wells in this aquifer are below MCLs. See Section 5.3.2 for a discussion of the sources and fates of contamination in ground water. The RAOs for White King Mine ground water are:

- Prevent any human exposure and future use of ground water beneath the stockpile with contaminant concentrations in excess of Federal and State drinking water standards or protective levels.

- Monitor ground water upgradient and downgradient of the stockpile to ensure that the potential beneficial uses of ground water (discharge to surface water) meet applicable standards (Oregon's State water quality standards (OAR 340-41-925) at the boundary of the waste management area with Augur Creek and/or to establish a trend toward background concentrations.

Beneficial Use Determination

Since an RAO has been established to monitor the ground water to ensure that the potential beneficial uses of the ground water are maintained, the following paragraphs describe the determination of beneficial ground water use for the Mines site.

A beneficial water use determination is required in accordance with OAR Chapter 340, Division 122. General categories of water use include drinking water, irrigation, livestock, industry, engineering, aquatic life (aquatic habitat), recreation, and aesthetic quality. The RI has documented that the Mines site is located in a remote area of Lake County, Oregon, approximately 17 miles from the nearest city (Lakeview). Water uses such as industrial process or engineering purposes are highly unlikely. The land in the vicinity of the Mines site is typically used for timber production or cattle grazing, not for food crop production. Thus, the use of ground water or surface water for irrigation of crops is highly unlikely. The natural background levels of radon, arsenic, and other constituents present within the ground water make it a poor drinking water source. (Under the NCP ground water at the site would likely be designated as Class II (Subclass IIB - a potential source of drinking water) where remediation goals are typically set at drinking water standards (MCLs) or background, whichever is higher)[6]. Ground water may discharge to surface water at a point down the Augur Creek valley. Therefore, the discharge of such ground water to surface water use is considered by the State as the potential beneficial use of ground water.

The only surface water body in the vicinity of the Mines site is Augur Creek. There are no current recreational uses (fishing, swimming, boating) of Augur Creek in the vicinity of the Mines site and future such uses are extremely unlikely due to the small size and intermittent flow of the creek. Augur Creek is hydraulically connected to the ground water as determined in the RI, but, as discussed above, there is no beneficial use of the ground water other than discharge to surface water. A likely beneficial surface water use for the Mines site would include Augur Creek as an aquatic habitat for macroinvertebrates and benthic organisms. Thus, to protect the aquatic habitat of Augur Creek, the discharge from ground water to surface water should meet Oregon's State water quality standards (OAR 340-41-925). Since the land use in the vicinity of the Mines site includes timber production and cattle grazing, water for livestock from either Augur Creek or a livestock watering well is also a potential water use.

8.2.2 Lucky Lass Mine

At the Lucky Lass Mine, the potential risks to a future resident exceed 1×10^{-6} due to exposure to arsenic and radionuclides in soil and arsenic and radon in ground water (as previously stated in section 7.1.3 residential exposure is not a reasonably likely future use although it was included in the risk assessment). The majority of the risks are associated with off-stockpile soils and shallow ground water below the stockpile. With the exception of specific surface soils, the overall levels of contamination in the Lucky Lass soils is much lower than that found at White King.

8.2.2.1 <u>Lucky Lass Soils</u>

The RAOs are as follows:

- Prevent direct contact with the contaminated soils to reduce potential risks from incidental soil ingestion and threat from external radiation exposure.
- Prevent any future use of stockpile soils with contaminant concentrations in excess of protective levels.

8.2.2.2 <u>Lucky Lass Mine Ground water</u>

Results of the human health BRA indicated cancer risks exceeding 1×10^{-6} and non-cancer hazard quotients exceeding 1 for future residential use of ground water from the shallow and deep aquifers. Radon was the only constituent of concern in shallow ground water. Arsenic and radon were the risk drivers in the deep (bedrock) aquifer. The concentrations of arsenic in ground water did not exceed the MCL at any location. The radon levels were similar to those detected in background samples. None of the radionuclides associated with mining activity were constituents of concern. As at the

[6] EPA's Superfund program uses EPA's Ground Water Protection Strategy as guidance when determining the appropriate remediation for contaminated ground water at CERCLA sites. This strategy establishes different degrees of protection for ground waters based on their vulnerability, use, and value. EPA's goal is to return usable ground water to their beneficial uses within a time frame that is reasonable given the circumstances of the site.

White King mine the state has determined that the potential beneficial use of the Lucky Lass ground water is discharge to surface water. EPA would classify this ground water as Class II (subclass IIB - a potential source of drinking water) where remediation goals are typically set at drinking water standards (MCLs) or background, whichever is higher. The RAOs for Lucky Lass Mine Ground water are:

- Monitor ground water upgradient and downgradient of the stockpile to ensure that the potential beneficial uses of ground water (discharge to surface water) meet applicable standards (Oregon's State water quality standards (OAR 340-41-925) at the boundary of the waste management area with Augur Creek and/or to establish a trend toward background concentrations.
- Prevent any human exposure and future use of ground water beneath the stockpile with contaminant concentrations in excess of Federal and State drinking water standards or protective levels.

8.3 ESTIMATED AREAS AND VOLUMES OF STOCKPILE MATERIAL AND POND WATER

Table 8-1 presents an estimate of the areas and volumes of media of concern including the White King Stockpiles, White King Mine pond, and the Lucky Lass Mine Stockpiles that was developed for the FS. The assumptions and data used in estimating the areas and volumes are also indicated in the table.

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SECTION 9

DESCRIPTION OF ALTERNATIVES

Many technologies were considered to clean up the Mines site. Appropriate technologies were identified and screened for applicability to site conditions. The potential technologies were then assembled into alternatives. Potential remedial alternatives for the Mines site were identified, screened, and evaluated in the FS. The range of alternatives developed included no action, institutional controls, containment, treatment, and disposal. The alternatives are identified by numbers used in the FS.

9.1 COMMON ELEMENTS OF EACH ALTERNATIVE

With the exception of the No Action Alternative, the remedial alternatives developed for the Mines site share certain components, such as institutional controls and monitoring requirements. Several of the alternatives require institutional controls (e.g., deed restrictions such as an easement or covenant) to limit or restrict certain uses of the Mines site and to ensure the integrity of the stockpile soil cover. These institutional controls and monitoring requirements are discussed in each alternative as appropriate and outlined in detail in the selected remedy (Section 12).

9.2 DESCRIPTION OF ALTERNATIVES

9.2.1 White King Stockpile Alternatives

9.2.1.1 <u>Alternative SP-1: No Action</u>

Estimated Capital Cost: $0

Estimated Annual O&M Cost: $0

Estimated Present Worth Cost: $0

Estimated Construction Time frame: None

CERCLA requires evaluation of a no-action alternative as a baseline reflecting current conditions without any cleanup effort. This alternative is used for comparison to each of the other alternatives.

9.2.1.2 <u>Alternative SP-2: Institutional Controls and Monitoring</u>

Estimated Capital Cost: $509,000

Estimated Annual O&M Cost: $36,000

Estimated Present Worth Cost: $956,000 (7% discount rate for 30 years)

Estimated Construction Time frame: None

This alternative consists of access restrictions, institutional controls, inspection and maintenance, and monitoring.

Access Restrictions

Access would be restricted by constructing a fence or barrier surrounding the stockpiles to prevent exposure to and disruption or use of the stockpile materials. In order to prevent disturbance of the stockpiled material from humans and cattle or medium-to-large animals, a barbed-wire fence, boulder barrier, or chain-link fence would be constructed around the stockpiles. For costing purposes, the chain-link fence option was used for the above cost estimate.

Institutional Controls

Land use restrictions would be put in place to prevent removal or residential use of stockpile material and installation of ground water wells. Because the White King stockpiles are located on both National Forest System Lands and private property, different mechanisms for land use restrictions will be required:

For private property land use restrictions would include proprietary controls such as an equitable servitude and easement (consistent with ODEQ's "Final Guidance for Use of Institutional Controls" (ODEQ, 1998). This is a legal instrument placed in the chain of title that provides access rights to a property for inspection and maintenance and monitoring and restrictions preventing residential use and installation of drinking water wells. This type of control shall be set forth in an EPA and ODEQ-approved form running with the land and enforceable by EPA and DEQ against present and future owners of the property. As an informational device the Mines site would be maintained on DEQ's Environmental Cleanup Site Information Database as long as the institutional controls remain in effect. One additional informational device is a deed notice to inform the public that contamination remains on private property.

On National Forest System Land an amendment to the Forest Plan would be made by the Forest Service to prohibit residential use and installation of drinking water wells at the Mines site. The area of the Mines site was withdrawn from mining by the Bureau of Land Management (BLM) on August 9, 1993 to protect the rehabilitation work to be done on the White King and Lucky Lass mine. This withdrawal will expire on August 9, 2013 (20 years) unless the withdrawal is extended (withdrawals can be extended for 20 years at one time) . The USFS will request that the BLM continue to maintain a withdrawal of the area of the stockpiles from mineral entry.

Inspection and Maintenance

Two inspections would be performed each year to confirm that land use restrictions have been effectively implemented on private parcels and National Forest System lands. During the site inspections an evaluation of whether the land use restrictions have been violated (e.g., material moved from the stockpiles, construction of housing etc.) on the private parcels and National Forest System lands within and adjacent to the Mines site would be performed. In addition, the private property owners would be contacted once per year to discuss the land use restrictions and potential future uses or property transactions that could affect the land with the stockpiled material.

Site maintenance would be conducted during two site inspections per year (spring and fall). The maintenance would address damages to the perimeter fence, gates, locks, warning signs, and the monitoring wells caused by inclement weather or vandalism.

Monitoring

Monitoring of various environmental media would be conducted to determine if constituents of concern are migrating and to ensure that there would be no unacceptable long-term risk. Post-remedial monitoring would be used to refine background levels, establish trends, and determine the need for additional action, if necessary. Sediment and surface water samples would be collected from Augur Creek. These samples would be collected upgradient of the protore stockpile, between the protore and overburden stockpiles, and downgradient of the overburden stockpile. The samples would be collected and analyzed annually and analyzed, at a minimum, for arsenic and total uranium.

Ground water samples also would be collected from alluvium and shallow bedrock wells upgradient and downgradient of the protore and overburden stockpiles. These depths are based on concentrations of radionuclides and inorganic constituents detected in the existing alluvium and shallow bedrock wells. Monitoring locations, sample frequency and indicator parameters will be defined in a site monitoring plan. Monitoring of ground water would ensure that the beneficial uses of ground water (aquatic life and livestock) are maintained and/or to establish trends.

9.2.1.3 <u>Alternative SP-3a: In-Place Containment</u>

Estimated Capital Cost: $4,316,000

Estimated Annual O&M Cost: $68,000

Estimated Present Worth Cost: $5,160,000 *(7% discount rate for 30 years)*

Estimated Construction Time frame: 5.5 months

The objective of this alternative is to regrade the two White King stockpiles and place a separate 12-inch soil cover over each stockpile. The access restrictions and monitoring components would be the same as those described in Alternative SP-2. Additional institutional control and inspection and maintenance requirements are added under this alternative to ensure the integrity of the two stockpile covers and prevent further erosion. This alternative would be performed in conjunction with a White King pond alternative that does not involve filling the pit with the stockpiled material (i.e., WKPW-1, WKPW-2, or WKPW-3).

Stockpile Regrading

The White King stockpiles would be regraded to provide slope stability, promote drainage, control erosion, minimize the area that requires final cover, and move the stockpile materials away from Augur Creek. For the protore stockpile, approximately 93,000 cubic yards of material would be regraded. This includes 68,000 cubic yards of stockpile material and 25,000 cubic yards of off-pile and haul road material that would be excavated and placed on the protore stockpile. As part of the regrading the sideslopes of the protore stockpile located adjacent to Augur Creek would be moved 20 feet away from the creek to reduce erosion during storm events. This would require the movement of approximately 8,000 cubic yards of material, which is included in the 68,000 cubic yards of material noted above. The final slopes of the protore stockpile would be approximately 8 percent on the top and 4:1 on the sideslopes.

At the overburden stockpile, approximately 157,000 cubic yards of material would be regraded. This includes 132,000 cubic yards of stockpile material and 25,000 cubic yards of off-pile and haul road material that would be excavated and placed on the overburden stockpile. As with the protore stockpile, the sideslopes of the overburden stockpile located adjacent to Augur Creek would be moved 20 feet away from the creek to reduce erosion during storm events. This would require the movement of approximately 19,000 cubic yards of material which is included in the 132,000 cubic yards of material noted above. The final slopes of the overburden stockpile would be approximately 2 percent on the top and 13 percent on the sideslopes.

Augur Creek Erosion Control

In addition to the 20-foot setback from Augur Creek, the sideslopes of the stockpiles would be protected from the erosional forces of Augur Creek. The maximum bank velocities along the protore and overburden stockpiles based on a 500-year flood are 3.01 and 1.88 feet per second (ft/sec), respectively. Because the slopes of the stockpiles that border Augur Creek would be potentially exposed to the erosional forces of Augur Creek, a 1-foot layer of 3 to 4-inch rip-rap to control erosion of stockpiles into Augur Creek would be constructed. This size rip-rap would typically be appropriate to control erosion up to 5.5 ft/sec.

Cover

The final area to be covered is estimated to be 18 acres at each stockpile. During the regrading operation, materials of sand/gravel composition would be covered with regraded clay-like material from the stockpiles. A "Clay-like material" is a term used to describe stockpile materials that consist of mixtures of clay and larger sized particles that exhibit significant plasticity in the field and low permeability in laboratory tests. This clay-like material would be placed in an estimated 9-inch layer (24,000 cubic yards) on the protore stockpile and an estimated 15-inch layer (37,000 cubic yards) on the overburden stockpile. The estimated thickness of clay- like material is dependent on the volume of clay-like material that is regraded at each stockpile. Based on volume estimates, 24,000 cubic yards and 37,000 cubic yards of clay-like material would be excavated and placed on the protore and overburden stockpiles, respectively, along with the sand/gravel like material. The compacted clay layer would further reduce the amount of precipitation that could infiltrate the stockpiles. After regrading and compacting, each stockpile would be covered with 9 inches of cover soil (24,000 cubic yards per stockpile) overlain by 3 inches of top soil (8,000 cubic yards per stockpile) and vegetation (18 acres per stockpile). The vegetation would likely consist of local climax vegetation (i.e., cool season grasses that are dormant in the summer and do not require long-term irrigation or other shallow rooted plants). The appropriate vegetation would be determined during the design phase. Cover soil could be borrowed from numerous sources including the Lucky Lass mine (1.5 miles from White King mine), National Forest System lands between the White King mine and Lucky Lass mine (1 mile from White King mine), as well as private sources located 3, 6, and 15 miles from the Mines site.

Access Restrictions

Access would be restricted by constructing a fence or barrier surrounding the stockpiles to prevent exposure to and disruption or use of the stockpile as described under Alternative SP-2.

Institutional Controls

Institutional controls would include the mechanisms described for Alternatives SP-2. In addition this alternative would also add restrictions to ensure the integrity of the two covers. No uses would be allowed which could penetrate the surface covers or impact their functional integrity. Placement of a deed notice can be made by EPA.

Inspection and Maintenance

Inspection and maintenance would include the land use assessment and maintenance activities described under Alternative SP-2. In addition, Alternative SP-3a would include inspection and maintenance requirements for the 12-inch soil covers and vegetation as well as the stormwater management system. As indicated under Alternative SP-2, two site inspections would be conducted each year. The first inspection in the spring would include assessment of the cover system and stormwater management system.

The cover system would be inspected for areas of significant erosion. Erosion would primarily occur in the form of gullies along the steeper sideslopes. Significant erosion could be defined as one deep gully, or loss of vegetation and multiple shallow gullies. Design guidelines will be developed to prevent run-on to the stockpiles via perimeter diversion swales and reducing/preventing gully propagation on the cover surface through the use of berms/swales located on the top slopes and sideslopes. These berms and swales will be sized to accommodate a 500-year 24-hour storm event. The eroded areas will be backfilled with cover soil and topsoil, and reseeded/mulched. The cover system will also be inspected for signs of settlement and subsidence. Areas showing signs of potential ponding or continued settlement would be backfilled and repaired as described for erosion gullies.

With respect to the stormwater management system, the drainage channels would be inspected for excessive erosion damage or lack of suitable vegetation. Erosion gullies would be backfilled, seeded, and mulched. Additional straw bale barriers may be required to protect the repaired area until vegetation is reestablished. Regrading and backfilling may be required to correct the slope or erosion along the channel lengths. Areas that continually erode would be evaluated to determine the need for permanent riprap structures in these areas. Erosion control devices such as silt fences, hay bales, and/or jute or straw mats would be inspected during the first year following construction completion. Silt fence posts that are no longer secure or vertical would be reinstalled. Damaged fabric would be repaired or replaced with new fabric. Hay bales that are no longer intact or secured to the subgrade would be replaced. If there is evidence that runoff is passing around the hay bales, then the hay bales would be replaced or repositioned, or additional hay bales would be added. Damaged jute or straw mats that are no longer secure would be reinstalled, if necessary, in the event vegetation has not been established.

Monitoring

Monitoring of various environmental media would be conducted as described under Alternative SP-2.

9.2.1.4 Alternative SP-3b:Containment and Consolidation at Protore Stockpile Location

As a result of input from the State agencies, and additional technical evaluation by EPA, Alternative SP-3b has been modified in two ways from its description in the FS. First, under this alternative the protore stockpile will be recontoured to insure that it is out of the Augur Creek Floodplain and in compliance with the floodplain and erosion standards of OAR 340-050-0060 and ORS 469.375. This will require excavation of approximately 138,000 cubic yards of the protore stockpile. (Alternative SP-3b in the FS included removal of 33,000 cubic yards of the Protore stockpile in order to set it back 20 feet from Augur Creek. This modification adds 105,000 cubic yards of material to the volume of material to be moved as estimated in the FS). The second change is the addition of 12 inches of soil to the consolidated stockpile (also referred to as the mine waste repository), resulting in a total soil cover thickness of 24 inches. This is a variation of cover "option B" presented in the FS which had a 12-inch soil and 6-inch rock cover. For the remainder of this ROD references to alternative SP-3b will include these two changes.

Estimated Capital Cost: $6,249,000

Estimated Annual O&M Cost: $54,000

Estimated Present Worth Cost: $6,919,000 (7% discount rate for 30 years)

Estimated Construction Timeframe: two 5.5-month construction seasons

The objective of this alternative is to excavate and place the overburden stockpile at the White King mine onto the protore stockpile at White King.

Stockpile Regrading

The Protore Stockpile will be reconfigured in order to remove stockpile material from the Augur Creek floodplain. It is estimated that approximately 138,000 cubic yards of material will need to be moved. **Figure 11-1** shows a conceptual design of the reconfigured protore stockpile, with the overburden stockpile on top, in relation to the Augur Creek floodplain and other major features at the Mines site.

The overburden stockpile (430,000 cubic yards) and off-pile, including portions of Augur Creek (35,000 cubic yards) and haul road material (15,000 cubic yards) will be excavated and relocated on top of the reconfigured protore stockpile. This material will be subsequently covered with regraded "clay-like material". "Clay-like material" is a term used to describe stockpile materials that consist of mixtures of clay and larger sized particles that exhibit significant plasticity in the field and low permeability in laboratory tests. The clay-like overburden would be compacted to impede burrowing animals. Field observations of the stockpiles indicate no presence of burrowing animals and suggest the overburden material is not physically suited for constructing burrows. Excavation of the 480,000 cubic yards of overburden stockpile and off-pile and haul road material will occur during the first construction season. Cover construction and planting of native grasses will occur during the second construction season. In addition, the second construction season will allow time for any additional regrading that might not have been completed during the first construction season.

Cover

A two-foot soil cover will be placed over the Mine waste repository. The total area that will require cover material is approximately 25 acres. The remedial design for the consolidated stockpiles shall include the following features: a low permeability lower layer utilizing the maximum thickness of regraded clay-like material over the top of the stockpile, use of natural features or drainage swales and french drains to divert surface water away from the consolidated stockpile, and to the extent practicable the final stockpile configuration shall fit into the natural topography. **Figure 11-2** shows a more detailed view of the proposed design features of the consolidated stockpiles. **Figure 11-3** depicts a cross section of the consolidated stockpile and **Figure 11-4** illustrates several potential design features of the consolidated stockpile. The final slopes of the stockpile will be approximately 4 percent on the top and 5:1 on the sides. The vegetation will consist of local climax vegetation (i.e., cool season grasses that are dormant in the summer and do not require long-term irrigation). The appropriate vegetation will be determined during the design phase. General cover soil can be borrowed from numerous sources including the Lucky Lass mine (1.5 miles from White King mine), National Forest System lands between the White King mine and Lucky Lass mine (1 mile from White King mine), as well as private sources located 3, 6, and 15 miles from the Mines site. The soil cover shall also include a storm water collection system to reduce the potential for erosion from or pooling of surface water. Final details on the soil cover and stockpile configurations will be developed during the design.

Reclamation

After excavation of the overburden stockpile, portions of the protore stockpile and off-pile and haul road areas, the disturbed areas will be reclaimed/revegetated with 3 inches of soil. The vegetation will consist of local climax vegetation (i.e., cool season grasses that are dormant in the summer and do not require long-term irrigation). The total area requiring reclamation/ revegetation is estimated to be 36 acres. Based on field observations during the RI, meadow areas situated on and downgradient of the stockpiles displayed characteristics (i.e., hydrophylic vegetation, hydric soils, and hydrology) satisfying the criteria for identification of a wetland area as outlined in the 1987 Corps of Engineers Wetland Delineation Manual (ACE, 1987). If there are any potential impacts on the wetlands due to the implementation of the final remedy, the remedial design will need to address these impacts.

Access Restrictions

Access would be restricted by constructing a fence or barrier surrounding the stockpile as described under SP-2 with the exception that the linear footage of fence would be less than fencing two stockpiles.

Institutional Controls

Land use restrictions will be put in place to prevent removal or residential use of stockpile material, installation of ground water wells, and to protect the integrity of the stockpile cover as described for Alternatives SP-2 and SP-3a.

Inspection and Maintenance

The White King waste repository cover will be inspected at a minimum of two times per year. The first site inspection will be conducted as soon as the Mines site is accessible in the spring (i.e., mid-May) and the second inspection will be conducted in late summer/early fall. The inspections will focus on the soil cover, sideslopes, perimeter fence, gates, locks, warning signs, and monitoring wells that could have been damaged by inclement weather or vandalism. Repairs will be conducted as necessary to correct the effects of settling, subsidence, erosion, vandalism, or other events to insure the integrity and effectiveness of the stockpile remedy. Visual indicators such as stressed vegetation, pooling of surface water indicating subsidence, also will be used to monitor effectiveness and integrity of the soil cover. The specific details for the stockpile monitoring and maintenance plan will be developed in design. (Additional details on maintenance of the stockpile is discussed later in this Section).

Confirmation that land use restrictions are effectively implemented will be assessed during site inspections. During the Mines site inspections, the private property and National Forest System lands within and adjacent to the Mines site will be assessed as to whether the land use restrictions have been violated (e.g., material removed from the stockpiles, construction of housing etc.).

Maintenance of the consolidated stockpile will include inspection and repair of the fences/physical barrier, gates, locks, warning signs, monitoring wells.

Monitoring

Monitoring of various environmental media would be conducted as described under Alternative SP-2.

9.2.1.5 Alternative SP-4a: Consolidation & Containment of the White King Stockpiles within the White King Mine Pit.

Estimated Capital Cost: $10,828,000

Estimated Annual O&M Cost: $55,000

Estimated Present Worth Cost: $11,510,000 (7% discount rate for 30 years)

Estimated Construction Timeframe: two 5.5-month construction seasons

The objective of this alternative is to excavate the White King stockpiles, dewater the White King pond, place the stockpile material within the empty pond, and provide a cover. Implementation of this alternative would include maintenance and monitoring to ensure the integrity of the cover. Institutional controls, access restrictions, monitoring components, and inspection and maintenance are the same as described in Alternatives SP-2 and SP-3a. This alternative would be implemented in coordination with a selected alternative for the White King pond that required dewatering of the pit.

White King Mine Pit Dewatering

The dewatering process would be determined by the alternative for the White King pond. Depending on the alternative selected for the White King pond, water may or may not be further treated prior to dewatering and may be discharged either to surface waters or applied to the land _

Consolidation and Containment of the White King Stockpiles Within the White King Mine Pit

The excavation, transport, and placement of soil materials contained in the overburden and protore stockpiles would likely occur over the period of two construction seasons, which are assumed to last from 15 May through 31 October. During the first season, the White King Mine pit would be dewatered and backfilled with soil from both the protore and overburden stockpile to an elevation a few feet above the current pond's normal water elevation, and graded to prevent ponding and promote surface water drainage. This also would include limited excavation to remove off-pile areas (35,000 cubic yards. Erosion control measures (silt fence and/or hay bales) would be established around the overburden and protore stockpiles and the material within the White King Pond to reduce the transport of material off-site during storm events. During the second season, the remaining soil (based on visual observations of meadow) from both the protore and overburden stockpiles would be excavated and transported to the mine pit. The haul road (15,000 cubic yards) would also be excavated. The material would be placed in a manner that joins the high wall to the west of the mine pit with the north, south, and east portions of the Mines site and regrades the area to the approximate surrounding topography.

It is estimated that approximately 930,000 cubic yards of stockpile material and 50,000 cubic yards of off-pile and haul road material would be placed within and above the White King Mine pit. It takes approximately 391,000 cubic yards of material to fill the pit to the current pond water elevation. Clay-like material would be placed first into the White King Mine pit to form a 20-foot layer of low permeability material. This would require approximately 240,000 cubic yards of the clay-like material. The sand/gravel stockpile material (151,000 cubic yards) would be placed in the remainder of the volume below the water table. A 15- to 20-foot low permeability layer would be constructed along the highwall with the clay- like material. The remainder of the sand/gravel material (223,000 cubic yards) would be placed above the current pond water elevation and encapsulated with the clay-like stockpile material along the highwall and by the 5-foot clay cover. The total volume of clay-like material above the water table is approximately 317,000 cubic yards. During the alter design phase, the most efficient method for material handling (i.e., scrapers, dump trucks, and/or conveyor belts) would be determined. The soil would be placed in loose lifts of 12 inches and compacted.

Backfill placement would occur in a manner that allows the displacement of water toward the mine shaft. Pumping operations from the mine shaft area would continue as the shaft was surrounded with soil. At this point, soil would be pushed directly into the mine shaft. Pumping operations would continue as soil in the mine shaft displaced water. If determined necessary in the field (i.e., high ground water flow or AMW), the mine shaft would be filled with soil material. With the mine shaft filled, the pumping platform would be removed from the shaft area and placed into a sump area, which is below the mine shaft. The mine shaft would then be grouted with a cement-based grout mixture. Grout holes would be drilled into the soil placed in the mine shaft area at approximate 5-foot intervals. The grout hole would be filled with grout through an injection pipe placed at the base of the mine. The grout mixture would seal mine voids and further stabilize soil within the mine shaft. Soil placement activities in the mine pit would continue as mine grouting progressed. Soil would be placed, graded, and compacted in a manner that provides drainage to the sump area. Soil backfilling and placement would continue until the mine pit was backfilled to an elevation a few feet above the existing pond water elevation.

During the second construction season excavation would begin at the protore stockpile. The soil excavation, transport, and placement processes; the engineering controls; would be similar to those used during the first construction season. The remaining soil from the stockpiles would be placed to join the high wall to the west of the mine pit with the adjacent topography. It is estimated that the remaining 480,000 cubic yards of material in the stockpiles would be relocated in approximately four consecutive months.

Temporary and Final Reclamation

The areas requiring temporary and final reclamation include the overburden stockpile, the protore stockpile, the White King pit, and the off-pile areas. Following the excavation of material from the stockpiles during the first construction season, the stockpile areas would be graded to provide for positive drainage. The stockpiles, the mine pit area, and the off-pile areas would be regraded and surrounded with a silt fence and/or hay bales until the second construction season. Once the soil from the both of the stockpiles has been placed into the mine pit area, both the overburden and protore stockpile areas and the mine pit area would be graded to promote positive drainage; these areas would then be revegetated. Additionally, silt fencing would be installed or existing fencing would be repaired to control the erosion and the migration of sediment until the seed established a suitable cover over these areas. Augur Creek would be relocated to its original meandering pattern. The final configuration of the creek would be determined during the design phase. As discussed for Alternative SP-3a, if there are any impacts on the wetlands due to the implementation of the final remedy, the remedial design would address these impacts.

Cover

The cover for this alternative would consist of 9-inch cover soil layer (28,000 cubic yards) overlain by 3 inches of topsoil (9,500 cubic yards) and vegetation (23 acres). Five feet of clay-like material would underlay the 12-inch cover. The cover soil and topsoil would be obtained from similar sources as identified for Alternative SP-3a. Inspection and Maintenance of the cover system would be similar to Alternative SP- 3a..

9.2.1.6 <u>Alternative SP-4d: Consolidation & Containment of the White King Stockpiles within the White King Mine Pit using a Permeable Treatment Wall.</u>

Estimated Capital Cost: $11,314,000

Estimated Annual O&M Cost: $55,000

Estimated Present Worth Cost: $11,996.000 (7% discount rate for 30 years)

Estimated Construction Timeframe: two 5.5-month construction seasons

The objectives of this alternative are the same as Alternative SP-4a, except that a permeable limestone wall would also be used in the pit in the direction of ground water flow in order to provide further protection from generation of acid mine drainage. The purpose of the treatment wall is to neutralize any acid rock drainage that potentially could be generated from either the stockpile material or the pit walls and impact ground water. The amount of limestone needed to neutralize the potential acidity is estimated to be 4,500 tons. The limestone layer would be placed such that the stockpile material can be placed on the limestone layer. Other neutralizing agents like quicklime or hydrated lime may also be considered instead of limestone in the construction of a permeable treatment wall.

9.2.1.7 Alternative SP-5: Excavation of Stockpiles and Disposal in a new "Off-Mine" Disposal Cell.

Estimated Capital Cost: $26,116,000

Estimated Annual O&M Cost: $61,300

Estimated Present Worth Cost: $26,840,000 (7% discount rate for 30 years)

Estimated Construction Timeframe: three 5.5-month construction seasons

The objective of this alternative is to dewater the White King pond, construct an engineered disposal cell located away from the mined area, place the excavated material from construction of the cell into the White King Mine pit, excavate and place the stockpiles into the disposal cell, and restore the stockpile areas with topsoil. The below-surface disposal cell would be constructed in a location above any influences of ground water. A compacted clay layer would be placed on the bottom of the cell and the cover would be a 12- inch soil as described in SP-3a. The tentative location of the new cell would be northwest of the Mines site on National Forest System Lands.

Institutional controls, access restrictions, monitoring components, and inspection and maintenance are the same as described in Alternative SP-3b.

"Off-Mine" Location

The area for construction of the disposal cell that met the screening guidelines in the FS was Alternate site A, located northwest of the White King Mine on National Forest System lands. This site sits on a basalt flow. According to the DEIS, the thickness of the basalt flow extends beyond 160 feet in depth. The site ranges from about 100 to 160 feet in elevation above Augur Creek. It was proposed that the disposal cell be placed into the hillside on the south-facing slope. Excavation into the hillside would allow for disposal of about 90 percent of the material below natural grade. For the purposes of evaluating the feasibility of an "off-mine" disposal alternative, Alternate site A was considered representative for an Aoff-mine@ location.

White King Mine Pit Dewatering

The dewatering process would be determined by the alternative for the White King pond. Depending on the alternative selected for the White King pond, water may or may not be further treated prior to dewatering and may be discharged either to surface waters or applied to the land. These alternatives are discussed in Section 9.3.2.

Consolidation/Containment of the Stockpiles Within the Cell and Backfill White King Mine Pit with Basalt Material

During the first season, the White King Mine pit would be dewatered and backfilled with excavated disposal cell material to an elevation approximately 5 feet above the current pond's normal water elevation, and graded to prevent ponding and promote surface water drainage. Construction and placement of stockpile material within the disposal cell would occur over three construction seasons. This would also include limited excavation to move off-pile areas at the Mine to the disposal cell. Clearing and grubbing of Alate seral@ timber (18 acres) on land subject to Forest Service management requirements would also be needed at the cell location. Erosion control measures would be established around the overburden and protore stockpiles and the material within the White King Pond to reduce the erosion of material off-site during storm events. The selection of stockpile materials to be placed in the cell could vary based on the physical, chemical and radiological properties. During the second and third season, the remaining soil from both the protore and overburden stockpiles would be excavated and transported to the cell.

It is estimated that approximately 930,000 cubic yards of stockpile material and 50,000 cubic yards of off-pile and haul road material would be placed within the cell. Approximately 18 acres of area would require clearing and grubbing to prepare the area for disposal cell construction. Late Seral trees and shrubs would be removed and disposed off-site. The cell would consist of regraded compacted clay-like material at the bottom. The cell would be constructed with clay-like stockpile material encapsulating the sand/gravel stockpile material with the higher arsenic and radium-226 containing material at the base of the cell. The cover would consist of a 9-inch cover soil layer (18,500 cubic yards) overlain by 3 inches of topsoil (6,000 cubic yards) and vegetation (15 acres).

Temporary and Final Reclamation

The areas requiring temporary and final restoration include the overburden stockpile, the protore stockpile, the White King Mine Pit, the off-pile areas, and the cell area. Following the excavation of material from the stockpiles during the first and second construction season, the stockpile areas, the mine pit and the cell would be graded to provide for positive drainage and surrounded with a silt fence and/or hay bales. Once the soil from both the stockpiles has been placed into the cell and the mine pit backfilled with the basalt material during the third construction season, both the overburden and protore stockpile areas and the mine pit would be graded to promote positive drainage; these areas would then be revegetated. Additionally, silt fencing would be installed or existing fencing would be repaired to control the erosion and the migration of sediment until the seed establishes a suitable cover over these areas. Augur Creek would be relocated to a meandering pattern similar to the original meandering pattern. The final configuration of the creek would be determined during the design phase. As discussed for Alternative SP-3a, if there are any impacts on the wetlands due to the implementation of the final remedy, the remedial design would address these impacts.

9.2.1.8 <u>Consolidation/Containment of the Stockpiles Within the Cell and Backfill White King Mine Pit with Basalt Material</u>

During the first season, the White King Mine pit would be dewatered and backfilled with excavated disposal cell material to an elevation approximately 5 feet above the current pond's normal water elevation, and graded to prevent ponding and promote surface water drainage. Construction and placement of stockpile material within the disposal cell would occur over three construction seasons.

This would also include limited excavation to move off-pile areas at the Mine to the disposal cell. Clearing and grubbing of "late seral" timber (18 acres) on land subject to Forest Service management requirements would also be needed at the cell location. Erosion control measures would be established around the overburden and protore stockpiles and the material within the White King Pond to reduce the erosion of material off-site during storm events. During the second and third season, the remaining soil from both the protore and overburden stockpiles would be excavated and transported to the cell.

It is estimated that approximately 930,000 cubic yards of stockpile material and 50,000 cubic yards of off-pile and haul road material would be placed within the cell. Approximately 18 acres of area would require clearing and grubbing to prepare the area for disposal cell construction. Late seral trees and shrubs would be removed and disposed off-site. The cell would consist of regraded compacted clay-like material at the bottom. The cell would be constructed with clay-like stockpile material encapsulating the sand/gravel stockpile material. The cover would consist of a 9-inch cover soil layer (18,500 cubic yards) overlain by 3 inches of topsoil (6,000 cubic yards) and vegetation (15 acres).

Temporary and Final Reclamation

The areas requiring temporary and final restoration include the overburden stockpile, the protore stockpile, the White King Mine Pit, the off-pile areas, and the cell area. Following the excavation of material from the stockpiles during the first and second construction season, the stockpile areas, the mine pit and the cell would be graded to provide for positive drainage and surrounded with a silt fence and/or hay bales. Once the soil from both the stockpiles has been placed into the cell and the mine pit backfilled with the basalt material during the third construction season, both the overburden and protore stockpile areas and the mine pit would be graded to promote positive drainage; these areas would then be revegetated. Additionally, silt fencing would be installed or existing fencing would be repaired to control the erosion and the migration of sediment until the seed establishes a suitable cover over these areas. Augur Creek would be relocated to a meandering pattern similar to the original meandering pattern. The final configuration of the creek would be determined during the design phase. As discussed for Alternative SP-3a, if there are any impacts on the wetlands due to the implementation of the final remedy, the remedial design would address these impacts.

9.2.2 White King Pond Water Alternatives

The alternatives considered for the water-filled excavation pit located in the White King Mine area include leaving the pond water in place, or pumping and discharging the pond water. The alternatives considered in-situ treatment, ex-situ treatment, or no treatment of the water to raise the pH level. Selection of an alternative for the pond water is interrelated to the selected alternative for addressing the White King stockpiles.

Summary of White King Pond Neutralization

During the period of preparation and review of the FS report, KMC proposed and EPA agreed to test neutralization of the White King pond. Prior to the neutralization effort, the pH level in the pond ranged from 3 to 4.5. Natural surface water typically has a pH level around 7 which is considered neutral. The neutralization effort consisted of adding lime to the White King pond during two events in 1998. The primary application was conducted on August 18, 1998, when approximately 9,000 lbs. (dry weight) of hydrated lime was applied in a slurry. A second application of lime occurred on September 13, 1998, and consisted of 200 lbs of hydrated lime apportioned in four paper sacks. Each sack was allowed to sink into the deepest location of the pond in order to target the more acidic pond water observed below the 40-foot depth. Monitoring of the pond occurred on a weekly or bi-weekly basis until November 19, 1998 (See **Table 9-1**). The results indicated that the vast majority of the pond water had a pH range from 6-7. An exception was found at the deepest portion of the pond where the pH level remained around 4. Analytical results for the neutralized pond water also showed substantially decreased levels (i.e., were precipitated by the lime application) of aluminum, beryllium, iron, zinc, and arsenic meeting all Oregon water quality criteria except for pH.

Monitoring of the pond in the spring and summer of 1999 showed that the pH level was beginning to decrease in the deepest portions of the pond. In October 1999 additional limestone rock was added to the deepest part of the pond to address ongoing acid generation and provide a more uniform and consistent buffering capacity. No further pond monitoring has been conducted since October 1999.

Table 9-1 compares the White King pond water quality, after the 1998 Pond Water Neutralization Study, with the PRGs (based on 1 x 10^{-6} protection level for a recreational user) and Summer and Goose Lake Basin Ambient Water Quality Standards. As shown in **Table 9-1**, with the exception of pH all PRGs and measured water quality criteria were met following the 1998 pond neutralization.

Results of the test neutralization indicate the pond can be neutralized. However, maintaining neutrality may require ongoing addition of neutralizing agents.

9.2.2.1 Alternative WKPW-1. No Action

Estimated Capital Cost: $0

Estimated Annual O&M Cost: $0

Estimated Present Worth Cost: $0

Estimated Construction Time frame: None

This alternative is used for comparison to other alternatives and does not include any type of action. No additional cost would be associated with this alternative. This alternative addresses the pond after the neutralization tests conducted in October 1999.

9.2.2.2 Alternative WKPW-2. Storm Water Management and Pond Monitoring

Estimated Capital Cost: $237,000

Estimated Annual O&M Cost: $24,000

Estimated Present Worth Cost: $535,000 (7% discount rate for 30 years)

Estimated Construction Time frame: none

This alternative consists of stormwater management and monitoring. Under this alternative no additional actions would be taken to maintain a neutral pH level in the pond.

Stormwater Management

Under this alternatives a diversion ditch would be constructed around the top of the highwall to collect and direct stormwater and minimize further erosion of the highwall.

Monitoring

Monitoring of ground water and pond water would be conducted twice per year to determine if constituents of concern are migrating and to ensure that there is no unacceptable risk from constituent migration through transport pathways. Post-remedial monitoring would be used to refine background levels, establish baseline trends, and determine the need for additional action, if necessary.

Ground water samples would be collected from alluvium and shallow bedrock wells upgradient and downgradient of the White King pond and analyzed, at a minimum, for total uranium, arsenic, and sulfate which act as indicator parameters. Monitoring of ground water would establish trends to ensure that the beneficial uses of ground water, are maintained.

White King pond water samples also would be collected and analyzed twice per year, at a minimum, for arsenic, aluminum, and pH.

9.2.2.3 <u>Alternative WKPW-3: Management of Pond Water Using In-Situ Neutralization</u>

Estimated Capital Cost: $237,000

Estimated Annual O&M Cost: $61,000

Estimated Present Worth Cost: $994,000 (7% discount rate for 30 years)

Estimated Construction Time frame: ongoing

Alternative WKPW-3, as described in the FS, was modified to address State and community input. These modifications include: the addition of controls to limit access and use of the pond while the neutralization is being evaluated; and, an expanded monitoring program to evaluate the effectiveness of neutralization and risks associated with arsenic in pond water and sediments. The following description of Alternative WKPW-3 incorporates these changes.

Stormwater Management

As in Alternative WKPW-2 a diversion ditch would be constructed around the top of the highwall to collect and direct stormwater and minimize further erosion of the highwall.

In Situ Neutralization

The pond water would be maintained at a neutral pH through periodic addition of pulverized limestone, limestone rock, hydrated lime or other neutralizing agents like soda ash. The limestone application rate and frequency is a function of factors such as existing water quality, source of acidification, volume of water, residence time of pond water, limestone application method, and limestone type, purity and particle size. The frequency and rate of liming would be determined during the design.

Post-Neutralization Pond Management

In addition to the liming, fertilizer may be added to the pond to stimulate primary biological activity. The biomass that would be produced from the biological activity would settle to the bottom of the pond and begin to develop a cover over the existing sediments. Any additional application volume and frequency of the fertilizer would be determined during the design and remedial action phase and will depend on the monitoring results.

Access Restrictions

Physical restrictions, such as fencing, would be required to control access to the pond while neutralization efforts and sediment risks are being evaluated. In order to prevent access by humans, livestock or medium-to-large animals, a barbed-wire fence or chain-link fence could be constructed around the pond. These restrictions may be eliminated in the future depending on the success of neutralization and the results of the sediment toxicity evaluation.

Institutional Controls

Land use restrictions would be put in place to prevent any use of the pond, such as for residential, recreational, or agriculture purposes and to prevent installation of ground water wells around the pond. Because the White King pond is located on both National Forest System Lands and private property, different mechanisms for land use restrictions would be required:

For private property land use restrictions would include proprietary controls such as an equitable servitude and easement (consistent with ODEQ's "Final Guidance for Use of Institutional Controls" (ODEQ, 1998). This is a legal instrument placed in the chain of title that provides access rights to a property for inspection and maintenance and monitoring to prevent use of the pond and installation of drinking water wells. This type of control shall be set forth in an EPA and ODEQ-approved form running with the land and enforceable by EPA and DEQ against present and future owners of the property. As an informational device the Mines site would be maintained on DEQ's Environmental Cleanup Site Information Database as long as the institutional controls remain in effect. One additional informational device is a deed notice to inform property owners of the existence of contamination in the White King pond. Placement of a deed notice can be made by EPA.

For National Forest Systems Land, an amendment to the Forest Plan (attached to this ROD) was made by the Forest Service to prohibit various uses of the Mines site including the White King pond. The uses restricted for the pond include residential, recreational use, and agricultural use. (See Section 12.2.1 for a complete discussion of these prohibitions). The area of the Mines site was also withdrawn from mining by the Bureau of Land Management (BLM) on August 9, 1993 to protect the rehabilitation work to be done on the White King and Lucky Lass mine. This withdrawal will expire on August 9, 2013 (20 years) unless the withdrawal is extended. The USFS would request that the BLM continue to maintain a withdrawal of the area of the stockpiles from mineral entry.

Inspection and Maintenance

Site inspections would be conducted twice per year. The inspection and maintenance activities would include inspection and repair of fences, gates, locks, warning signs, and monitoring wells caused by inclement weather or vandalism.

Monitoring

The monitoring of ground water and pond water are similar to that described for Alternative WKPW-2. Additional monitoring is added under this alternative to address the pond sediments and effectiveness of neutralization.

The monitoring/sampling of the pond (water and sediments) and ground water (including any surface discharge) will occur at a minimum of two times per year. A monitoring plan including a quality assurance program plan and a sampling plan would be submitted for EPA approval during the remedial design. The overall purpose of the monitoring is to determine the effectiveness of pond neutralization, to refine background levels, establish trends and further evaluate the risk associated with pond water and sediments. Specific objectives include: Improve the conceptual site model for the pond; describe the geochemical processes affecting pond chemistry and aquatic life; identify the sources, nature and extent of COCs in sediments; and, evaluate toxicity, bioavailability, and species exposure to pond sediments.

The results of each seasons sampling and monitoring data would by reviewed annually by the EPA. The information will be evaluated to determine if the pond neutralization is effective and what risks are associated with pond sediments. Based on limited sampling data risks have already been associated with pond sediments. Further evaluation of risks should utilize site-specific factors such as chemical bioavailability and toxicity using specific organisms of concern that typically inhabit similar environments. At a minimum the following factors shall be considered during this evaluation:

- As specified in OAR 340-122-0115 acceptable risk level for populations of ecological receptors" means a 10 percent chance, or less, that no more than 20 percent of the total local population will be exposed to an exposure point value greater than the ecological benchmark value for each contaminant of concern and no other observed significant adverse health effects on the health or viability of the local population.
- "Ecological benchmark value" means the no-observed-adverse-effect level (NOAEL) for individual ecological receptors considering effects on reproductive success or the medial lethal dose or concentration (LD50 or LC50) for populations of ecological receptors.

9.2.2.4 <u>Alternative WKPW-4: Land Application of Pond Water without additional In-situ Treatment</u>

Estimated Capital Cost: $1,624,000

Estimated Annual O&M Cost: $0

Estimated Present Worth Cost: $1,624,000 (7% discount rate for 30 years)

Estimated Construction Time frame: 60 days

The objective of this alternative is to pump the White King pond and dispose of the water on the land within the immediate vicinity of the Mines site. The area needed for land application is estimated to be approximately 300 acres. This alternative would be implemented in coordination with a selected alternative for the White King stockpiles addressing consolidation/containment of stockpiles within the mine pit. No additional treatment of water would occur prior to land application.

White King Mine Pit Dewatering

The dewatering process for the mine pit would be accomplished using pumps mounted on a floating platform. To empty the pond in a one-month period, a pump or a combination of pumps capable of removing approximately 3,400 gpm would be required. Using a 30 percent safety factor, it is estimated that the pond would be dewatered at a pumping rate of 4,500 gpm for 30 days. Based on existing meteorological data, approximately 0.7 inch of rainfall could be expected during the dewatering process. The additional volume of water generated from rainfall is not expected to delay the dewatering process. Pumping operations would be monitored and maintained by operators 24 hours per day. Water removed from the pond would be managed in accordance with the selected alternative for the White King pond water.

Land Application

As discussed above, the dewatering rate needed to dewater the pond in 30 days is estimated to be 4,500 gpm. The recommended system in the FS for land application was a pressurized overhead sprinkler system with a manifold to allow water to be diverted to various areas during the dewatering period. The final selection of the type of land application system and locations would occur during the design phase. Based on the EPA slow rate design method, it was recommended that the maximum land application rate should be 1-inch per day. Based on the design dewatering rate of 4,500 gpm and a design land application rate of 1-inch per day, the area needed for land application is estimated to be 238 acres. Using a safety factor of 1.25, the maximum area needed for land application is estimated to be 300 acres.

9.2.2.5 Alternative WKPW-5a: Land Application of Pond Water after Additional In-Situ Treatment.

Estimated Capital Cost: $1,664,000

Estimated Annual O&M Cost: $0

Estimated Present Worth Cost: $1,664,000 (7% discount rate for 30 years)

Estimated Construction Time frame: 60 days

This alternative is the same as the Alternative WKPW-4, except that the pond water would be treated, if necessary, before being applied to the land in order to meet any applicable land application requirements. The in situ neutralization of the White King pond water is the same as described for Alternative WKPW-3. This alternative would be implemented in coordination with a selected alternative for the White King stockpiles addressing consolidation/containment of stockpiles within the mine pit.

9.2.2.6 Alternative WKPW-5b: Surface Water Discharge of Pond Water after Additional In-Situ Treatment

Estimated Capital Cost: $891,000

Estimated Annual O&M Cost: $0

Estimated Present Worth Cost: $891,000 (7% discount rate for 30 years)

Estimated Construction Time frame: 60 days

Alternative WKPW-5b is the same as Alternative WKPW-4 except that the treated water would be discharged to Augur Creek. This alternative would be implemented in coordination with a selected alternative for the White King stockpiles addressing consolidation/containment of stockpiles within the mine pit. The dewatering component would be the same as discussed for Alternative WKPW-4. The treatment and discharge components are described below.

Surface Water Discharge

Under this alternative, the treated pond water would be discharged to Augur Creek at a rate of approximately 4,500 gallons per minute or 10 cubic feet/second. A riprap outfall structure would be constructed to prevent erosion of the Augur Creek which has normal flows ranging from 3 to 150 cfs depending on the time of year. Thus, only limited erosion control may be necessary to protect Augur Creek during discharge from the pond. Following the completion of the mine pit dewatering, the outfall structure would be removed.

9.2.2.7 Alternative WKPW-6a: Land Application of Ex-situ Treated Pond Water.

Estimated Capital Cost: $1,731,000

Estimated Annual O&M Cost: $0

Estimated Present Worth Cost: $1,731,000 (7% discount rate for 30 years)

Estimated Construction Time frame: 60 days

The objective of this alternative is to pump the White King pond water, conduct ex-situ treatment, and then land apply the water over a large on-site area. This alternative is the same as the Alternative WKPW-4, except that the pond water would be neutralized ex-situ before the land application. The neutralized water would also go through portable sand media filters prior to land application. The details of ex-situ treatment are presented below.

Ex-situ Treatment

The ex-situ treatment would consist of raising the pH of the pond water to between 7 and 8. Based upon estimates in the FS a total of approximately 21 tons of 50% sodium hydroxide (using a safety factor of 1.5 to account for uncertainties associated with the initial pH, volume of water, and effectiveness during application) would be required to neutralize the acidity of the pond.

The ex-situ pH adjustment can be performed either in-line or in a tank. For purposes of the FS in line pH adjustment is discussed. For in-line pH adjustment, it is estimated that an analyzer, sensor probes, a 12-inch carbon steel static mixer, and an injection assembly can be mounted directly on the main line of the land application system. Sodium hydroxide would be fed directly into the pipeline and the pH adjustment would take place inside the pipeline. A control system would be used to ensure appropriate chemical addition rates. A chemical feed system would be needed. The chemical feed system would consist of a 5,000-gallon polyethylene tank (chemical storage tank), a 100-gallon polyethylene tank (day tank), a chemical feed pump, and an agitator. The selection of the appropriate pH adjustment equipment would take place in the remedial design process. The neutralized water would go through portable sand media filters to remove any precipitates prior to land application.

9.2.2.8. <u>Alternative WKPW-6b: Surface Water Discharge of Ex-Situ Treated Pond Water</u>

Estimated Capital Cost: $1,011,000

Estimated Annual O&M Cost: $0

Estimated Present Worth Cost: $1,011,000 (7% discount rate for 30 years)

Estimated Construction Time frame: 60 days

This alternative is the same as WKPW-5b except that the treatment of pond water would take place ex-situ.

Alternative WKPW-6b involves pumping the White King pond water, performing ex-situ treatment, and then discharging the water to Augur Creek. This alternative is the same as the Alternative WKPW-5b except that the treatment of pond water would take place ex-situ. The ex- situ pH adjustment would be the same as discussed in the Alternative WKPW-6a.

9.2.3 Lucky Lass Stockpile Alternatives

9.2.3.1 <u>Alternative LL-1: No Action.</u>

Estimated Capital Cost: $0

Estimated Annual O&M Cost: $0

Estimated Present Worth Cost: $0

Estimated Construction Time frame: None

CERCLA requires evaluation of a no-action alternatives as a baseline reflecting current conditions without any cleanup effort. This alternative is used for comparison to each of the other alternatives.

9.2.3.2 <u>Alternative LL-2: Institutional Controls</u>

Estimated Capital Cost: $169,000

Estimated Annual O&M Cost: $15,000

Estimated Present Worth Cost: $355,000 (7% discount rate for 30 years)

Estimated Construction Time frame: one month

This alternative consists of institutional controls, access restrictions, and inspection and maintenance similar to Alternative SP-2. No monitoring of environmental media is included.

Access Restrictions

Physical restrictions to reduce access to human and animals include a fence that would encompass the areas estimated to exceed protective cleanup goals for radium-226 and arsenic. The signs, fence, and inspection and maintenance activities would be the same as that described for Alternative SP-2.

Institutional Controls

Because the Lucky Lass mine area is situated entirely on National Forest System land, institutional controls would be implemented through Forest Service mechanisms only. Land use restrictions will be put in place to prevent residential or recreational use at the mine, installation of ground water wells, and removal of stockpile material. An amendment to the Forest Plan (attached to this ROD) has been made by the Forest Service to prohibit these uses. Various private individuals have asserted unpatented mining claims that confer ownership status to the Lucky Lass mine. However, the area of the Mines site was withdrawn from mining by the Bureau of Land Management (BLM) on August 9, 1993 to protect the rehabilitation work to be done on the White King and Lucky Lass mine. This withdrawal will expire on August 9, 2013 (20 years) unless the withdrawal is extended. The USFS will request that the BLM continue to maintain a withdrawal of the area of the stockpile from mineral entry. As an informational device the Mines site will be maintained on DEQ's Environmental Cleanup Site Information Database as long as the institutional controls remain in effect.

9.2.3.3 <u>Alternative LL-3: Removal and Containment of Material Exceeding PRGs with the White King Stockpile</u>

Estimated Capital Cost: $349,000

Estimated Annual O&M Cost: $15,000

Estimated Present Worth Cost: $535,000 (7% discount rate for 30 years)

Estimated Construction Time frame: one month

This alternative involves excavating soils from the Lucky Lass stockpile and adjacent areas that exceed the EPA cleanup goals for arsenic and radium-226 and restoring the excavated area with topsoil.

Soil Excavation

All surface soils that exceed the cleanup level for arsenic and radium-226 (See **Table 8-1**) will be excavated and placed within the consolidated White King Stockpile. Most of these soils have been identified in the Lucky Lass meadow, downhill from the overburden pile and Lucky Lass pit, with the highest uranium activities occurring in the upper 1 to 2 feet of soil. Other soils with elevated radium-226 activity occur on top of the Lucky Lass stockpile as a reddish-black rock, which contrasts with the lower activity chalk-colored overburden. It is estimated that approximately 3,000 cubic yards of soil exceed a cleanup level of 3.6 pCi/g for radium-226 and 38 mg/L for arsenic. A field screening methodology for identification of these soils, similar to the approach at White King, will be developed during the design. The excavated areas will be restored to existing grade including 3 inches of topsoil. The Lucky Lass stockpile material that has been impacted by drainage from the Lucky Lass pond will also be excavated and moved so that there is no erosion impact of Lucky Lass pond drainage on the Lucky Lass stockpiles. The excavated material will be regraded with the Lucky Lass stockpiles and the excavated area will be restored with riprap to reduce erosion. Recontouring of the Lucky Lass Mine overburden stockpile may be necessary if portions of the stockpile are used as a borrow source for the White King consolidated stockpile soil cover. Such activities may include, but are not limited to, regrading the stockpiles to provide slope stability, promote drainage, and control erosion; placement of topsoil; and establishment of vegetation on the stockpile. No future monitoring or inspection and maintenance of the Lucky Lass stockpile will be required.

Access Restrictions

Short-term access restrictions will include physical restrictions (e.g., fencing), warning signs, and safety measures until completion of the remedial action.

Institutional Controls

Institutional controls would be required to prevent removal or residential use of the remaining Lucky Lass stockpile and prohibit installation of ground water wells within the stockpile. These controls would be the same as discussed under LL-2.

9.2.3.4 <u>Alternative LL-4: Removal and Containment of Stockpile and Disposal in "Off-Mine" Disposal Cell</u>

Estimated Capital Cost: $2,656,000

Estimated Annual O&M Cost: $9,000

Estimated Present Worth Cost: $2,768,000 (7% discount rate for 30 years)

Estimated Construction Time frame: 5.5 months

Alternative LL-4 involves excavating all the Lucky Lass Mine stockpiles (260,000 cubic yards) and the off-pile areas that exceed PRGs (3,000 cubic yards) and placing them in the proposed "off-mine" disposal cell. This alternative would be implemented in conjunction with the alternatives for the White King Mine stockpiles that provide for excavation and disposal into an "off-mine" cell (Alternative SP-5) and backfill of the White King pit with clean or treated material (Alternatives SP-4b and SP-4c). The excavated areas would then be restored with 3 inches of topsoil. The institutional controls, access restrictions, and inspection and maintenance for the Lucky Lass stockpiles and adjacent areas would be similar to the provisions in LL-2.

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SECTION 10

COMPARATIVE ANALYSIS OF ALTERNATIVES

The NCP requires that each remedial alternative analyzed in detail in the FS be evaluated according to specific criteria. The purpose of this evaluation is to promote consistent identification of the relative advantages and disadvantages of each alternative, thereby guiding selection of remedies offering the most effective and efficient means of achieving site cleanup goals. There are nine criteria by which feasible remedial alternatives are evaluated. While all nine criteria are important, they are weighed differently in the decision-making process depending on whether they describe protection of human health and the environment or compliance with Federal or State statutes and regulations, such as the State of Oregon rules for disposal of radioactive material (ORS 469.375) (threshold criteria), a consideration of technical or socioeconomic merits (primary balancing criteria), or involve the evaluation of non-EPA reviewers that may influence an EPA decision (modifying criteria).

10.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This criterion evaluates whether an alternative achieves and maintains adequate protection of human health and the environment.

10.1.1 White King Mine Stockpile Alternatives

All the alternatives, except the no-action alternative (SP-1), would be protective of human health and the environment, by eliminating, reducing, or controlling the risks posed by the stockpile material. Because the "no-action" alternatives (SP-1) is not protective of human health and the environment it was eliminated from further consideration under the remaining eight criteria. Alternative SP-5 provides the greatest level of protection against potential risk by placing the stockpile material in an engineered disposal cell above any influences of ground or surface water. Alternatives SP-3a, SP-3b, SP-4a and SP-4d would be equally protective of the environment in reducing migration of COCs to ground water, surface water or surface soils. Although Alternatives SP-3a and SP-3b reduce runoff or erosion, Alternatives SP-4a and SP-4d would nearly eliminate the potential for surface erosion as most of the material would be placed below grade in the White King Mine Pit. The addition of a permeable limestone wall in Alternative SP-4d would neutralize any potential acidic water generated in the pit and prevent any impacts to ground water. Alternative SP-2 provides a fence (or barrier) to prevent access by medium-to-large mammals, domestic cattle, and humans; however, it does not provide protection for small mammals or prevent erosion and the protectiveness depends on the effectiveness of physical and land-use restrictions.

10.1.2 White King Pond Alternatives

Alternatives WKPW-4 through WKPW-6b achieve complete protection by treating the water, either in-situ or ex-situ, and discharging the water to land or surface water. The White King Pond is then eliminated and filled depending on which stockpile alternative is selected. Under alternative WKPW-3 human and ecological risks from the low pH pond water would be eliminated through neutralization. However, risks associated with pond sediments would not necessarily be addressed through neutralization alone and further action such as sediment capping or dredging may be required. The protectiveness of WKPW-2 depends on the effectiveness of continuation of land use and physical restrictions.

Because the "no-action" alternative (WKPW-1) is not protective of human health and the environment it was eliminated from further consideration under the remaining eight criteria.

10.1.3 Lucky Lass Mine Stockpile Alternatives

All the Lucky Lass Stockpile Alternatives, except the no-action alternative (LL-1) would be protective of human health and the environment. Alternative LL-4 provides the greatest level of protectiveness by placing all the stockpile material into an engineered "off-mine" disposal cell. Alternative LL-3 provides protection by excavating and containing the material (within the White King Stockpiles) that exceed the radium-226 PRG. The protectiveness of Alternative LL-2 relies on the effectiveness of physical controls (fencing) and land use restrictions to prevent exposure and/or use of stockpile materials at the Mines site.

Because the "no-action" alternative (LL-1) is not protective of human health and the environment it was eliminated from further consideration under the remaining eight criteria.

10.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121(d) of CERCLA and 40 CFR 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate requirements "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, or contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a State in a timely manner and that are more stringent than Federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate.

10.2.1 White King Mine Stockpile Alternatives

As discussed in Sections 9.2.1.4 one significant requirement for the Mines site is the State of Oregon rules for disposal of radioactive material. ORS 469.375 prohibits siting of a waste disposal facility for uranium mine overburden and other radioactive material in Oregon unless the disposal site meets a number of criteria to assure protection of the health and safety of the public and of the environment. Among other criteria, ORS 469.375 and OAR 345-050-0060 provide that the site for disposal of radioactive material must not be located in or adjacent to an area that is subject to river or creek erosion within the lifetime of the facility or is within the 500-year floodplain of a river, creek, or stream. The OOE has determined that Alternative SP-3b (as modified in this ROD) would comply with these requirements. Similarly, Alternative SP-5 would also meet these requirements in that the disposal cell would be well above the Augur Creek floodplain. OOE has determined that all other stockpile Alternatives would not meet these requirements since all or part of the stockpile materials would remain within the floodplain of Augur Creek.

10.2.2 White King Pond Alternatives

White King pond water alternatives 4 through 6b would meet all ARARs through treatment of pond water or land application. The No Action (WKPW-1) and Institutional Controls (WKPW-2) Alternatives would not meet all ARARs. With respect to WKPW-2 , the NCP requires that institutional controls shall not substitute for active response measures as the sole remedy unless active measures are determined not to be practicable based on the balancing of trade-offs among alternatives. As demonstrated in this section, active measures beyond institutional controls are practicable. It is expected that WKPW-2 will meet all ARARs however, further monitoring and evaluation of the pond will evaluate the ability to achieve Oregon's State water quality standards (OAR 340-41-925).

10.2.3 Lucky Lass Mine Stockpile Alternatives

At Lucky Lass Alternative LL-2 would not comply with State requirements for mining reclamation under OAR 632-35 or OAR 345-95-118. This alternative would also not comply with ARARs for material exceeding remediation goals. LL-3 and LL-4 would meet these and all other ARARs.

10.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

This criterion evaluated the ability of an alternative to maintain protection of human health and the environment over time. The following factors were considered in the evaluation of long-term effectiveness:

- Magnitude of the residual risks remaining at the completion of remedial activities.
- Adequacy and long-term reliability of management and technical controls for providing continued protection from the residual risks.

10.3.1 White King Mine Stockpile Alternatives

Alternatives SP-3a, SP-3b, SP-4a, and SP-4d would all be reliable and require similar degrees of monitoring and maintenance. Alternatives SP-3b, SP-4a, SP-4d, SP-5 would consolidate the two stockpiles either at the protore stockpile, in the White King pit, or in a new disposal cell. These alternatives would have a slight advantage over SP-3a with respect to a reduction in the area that would be subject to surface runoff and erosion and require continued maintenance. In addition, during consolidation of the stockpiles, natural clay like material would be placed on top of the stockpiles which would further reduce infiltration, radon emanation, gamma emissions and isolate the most contaminated material from erosion and direct contact. These alternatives would tend to be more reliable and require somewhat less monitoring and maintenance than leaving the stockpiles in place as in Alternative SP-3a. Alternatives SP-3b (as modified), and SP-5 are outside the floodplain of Augur Creek. This makes them less susceptible to creek erosion and more reliable than the other stockpile alternatives. Alternative SP-2 requires physical and land use restrictions, the long-term effectiveness is dependent upon the implementation, maintenance, and monitoring of the institutional controls. The fence would prevent biointrusion by medium to large mammals, but would not completely prevent biointrusion for smaller mammals. In addition institutional controls do not address infiltration and percolation that results from leaving the stockpiles uncovered.

10.3.2 White King Pond Alternatives

Alternatives WKPW-4, WKPW-5a, WKPW-5b, WKPW-6a and WKPW-6b require dewatering of the pond and are effective in the long-term but to varying degrees. All these alternatives will be completed in approximately 60 days and there will be minimal residual risk, no potential for future exposure from the pond water, no need for long-term replacement, and no concerns for long-term reliability. Alternative WKPW-3 provides less long-term effectiveness and permanence due to the potential need for continued neutralization in order to maintain stable pH conditions and improved water quality. If neutralization is effective in the long-term, ecological risks from exposure to acid pond conditions may be eliminated. However, it is unclear whether ecological risks from the pond sediments would be eliminated. The long-term effectiveness of Alternative WKPW-2 is dependent upon the effective implementation and monitoring of institutional controls which may be less effective due to the remote location of the pond. In addition the residual risks to aquatic organisms from the pond water and sediments would not be addressed by Alternative WKPW-2.

10.3.3 Lucky Lass Mine Stockpile Alternatives

Alternatives LL-3 and LL-4 provide the greatest degree of assurance of long-term effectiveness for materials exceeding PRG levels by either containment or removal. Both alternatives have low residual risk since they eliminate the future exposure to material containing COCs by humans and ecological receptors. Alternative LL-2 is dependent upon the effective implementation and monitoring of the institutional controls and fencing.

10.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

CERCLA states a preference for selecting remedial actions that principally employ treatment technologies to permanently and significantly reduce toxicity, mobility or volume of the hazardous substances at the site. There is also a preference for treatment of "principal threats" at a site through destruction of toxic COCs, reduction of the total mass of toxic COCs, irreversible reduction in constituent mobility, or reduction of total volume of media containing COCs. See Section 11 for a discussion on principal threats at the site.

In determining an appropriate range of alternatives for sites with high volume/low risk waste, EPA has stated its position in the regulations as well as guidance documents. Specifically, EPA expects to use engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable." 40 CFR 300.430(a)(iii)(B). In addition EPA Guidance for Conducting RI/FS under CERCLA, Interim Final (EPA, 1988) states "Development of a complete range of treatment alternatives will not be practical in some situations. For example, for sites with large volumes of low concentrated wastes such as some municipal landfills and mining sites, an alternative that eliminates the need for long-term management may not be reasonable given site conditions, the limitations of technologies, and extreme costs that may be involved."

Thus, given the large volume (980,000 cubic yards which included stockpiles, haul roads, and off-pile material) of overburden material present at the Mines site, limitations of treatment technologies potentially implementable for the stockpile material, extreme costs, and the low risk nature of the majority of the material, treatment was not considered in the FS to be practical. However, because CERCLA sets forth a statutory preference for remedial actions in which treatment permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances, the FS evaluated treatment alternatives for the stockpiled material. Treatment technologies that were retained for assembly into alternatives include chemical stabilization/solidification, permeable treatment walls, and physical segregation. Chemical stabilization/solidification may be appropriate for a small volume of the highly contaminated material ("hot spot"). A permeable treatment wall may potentially be used to prevent leaching of AMW from the stockpile material following placement into the White King pond. Physical separation of the material by physical or chemical properties may potentially be used as a component of the stockpile alternatives.

The following considerations were applied to each alternative:

- The treatment processes the remedy will employ, and the materials they will treat.
- The amount of hazardous materials that will be destroyed or treated, including how the principal threat(s) will be addressed.
- The degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude).
- The degree to which the treatment will be reversible.
- The type and quantity of treatment residuals that will remain following treatment.
- Whether the alternative would satisfy the statutory preference for treatment as a principal element.

It should be noted that there is no treatment technology known to reduce or prevent radioactive decay. Volume reduction of radioactive material could be performed in certain circumstances. However, volume reduction would not be appropriate at the overburden stockpiles since the larger particles (sand/gravel) have the high activity as opposed to fine particles having high activity which could be separated from large particles with low activity. In addition, given the large volume (980,000 cubic yards) of overburden material present, limitations of treatment technologies potentially implementable for the stockpile material, extreme costs, and the low risk nature of the majority of the materials, treatment is not practical. In fact, due to the large volume of material, solidification and stabilization, an effective and reliable treatment technology, was not cost-effective and was screened out in the FS.

10.4.1 White King Mine Stockpile Alternatives

Alternative SP-2 does not use any treatment process and there is no reduction in toxicity, mobility, or volume.

There is no active chemical or biological treatment of the stockpile material using Alternatives SP-3a, or SP-3b, but to the extent reduction of potential for acid generation leaching from the piles is seen as beneficial, these alternatives would reduce mobility. Specifically, the grading and recontouring will compact stockpile soils, utilize clay-like soils to minimize percolation and provide a secure cover. Modeling conducted during the FS predicted that Alternatives SP-3a, and SP-3b would reduce the total volume of percolation through the stockpile material by 53 percent and 65 percent as compared to Alternative SP-2, thereby reducing the mobility of COCs. Although containment is not a treatment process, it also reduces the mobility of radon, gamma emissions and transport of stockpile COCs via wind and water erosion. The 12-inch cover in Alternative SP-3a decreases gamma emissions by 98 percent and radon emissions by 26 percent. The benefits of containment would be reduced if the cover thickness is not maintained. Annual maintenance would help eliminate this concern.

Alternatives SP-3b provides the same level of reduction in mobility as Alternative SP-3a. However, the 7.5-foot compacted clay-like material layer over the higher activity gravel/sand material would further reduce radon and gamma emission.

For Alternative SP-4a, acid mine water generation is prevented by inhibiting oxygen transport. Physical handling of the stockpile materials to deposit them in the pit would result in reduced mobility of COCs using clay-like materials for the bottom of the pit. Modeling conducted during the FS predicted that, using Alternatives SP-4a and SP-4d, the total volume of percolation through the stockpile material would be reduced by 98 percent as compared to Alternative SP-2, thereby potentially reducing mobility of COCs. It should be noted that the model cannot account for lateral ground water flow through backfilled stockpile material that would ultimately be below the water table. Alternative SP-4d provides treatment by neutralizing any AMW generated that could migrate away from the pit. Both Alternatives SP-4a and SP-4d would reduce the radon and gamma emission to negligible levels via a 5-foot compacted clay-like material layer beneath the 12-inch soil cover similar to Alternative SP-3b. The 12-inch soil cover would lose 25% of its thickness without annual maintenance due to wind and water erosion over 1,000 years.

Alternative SP-5 would result in similar reductions in mobility of COCs as the physical handling operations and reduction in radon and gamma emissions discussed for Alternatives SP-4a and SP-4d. The modeling predicts that Alternative SP-5 would reduce the total volume of percolation through the stockpile material by 97 percent when compared to Alternative SP-2. Alternative SP-5 offers the same treatment for AMW as Alternative SP-4a, but the treatment may not be as successful for inhibiting generation of AMW as other alternatives because the clean material (basalt) used in backfilling may not be as effective in inhibition of oxygen transport as clay-like stockpile material.

10.4.2 White King Pond Alternatives

Alternatives WKPW-2 and WKPW-4 do not use any active treatment process as a principal element. WKPW-4 relies on natural attenuation to reduce the toxicity and mobility of COCs following land application.

Alternatives WKPW-3, WKPW-5a and WKPW-5b involve in-situ neutralization with hydrated lime or other materials as the principal element for treating pond water. The 1998 Neutralization Treatability Study preliminary results indicated that, in addition to stabilization of the pH, COCs in surface water were reduced to concentrations below both PRGs and surface water discharge standards. Because of the increase in pH of pond water, some of the calcium, magnesium, aluminum, and iron salts precipitated along with the COCs. This results in decreased concentrations in the water column but an increase in concentrations of COCs in pond sediments.

Alternatives WKPW-6a and WKPW-6b involve ex-situ neutralization with sodium hydroxide and sand filtration as the principal element for treating pond water to reduce toxicity and volume of COCs.

10.4.3 Lucky Lass Mine Stockpile Alternatives

None of the Lucky Lass alternatives include active chemical or biological treatment as a principal element. Although Alternatives LL-3 and LL-4 do not include treatment, both of these alternatives reduce the potential for mobility of COCs via suspended solids transport at the Lucky Lass mine by excavating and removing the soil that is above PRGs. In addition, both these alternatives excavate the material that is subject to the minimal erosive forces of discharge from the Lucky Lass pond. In both alternatives (LL-3 and LL-4), the material would be contained beneath an engineered cover system as part of the selected White King stockpile alternative.

10.5 SHORT-TERM EFFECTIVENESS

The short-term impacts of alternatives were assessed by considering the following: (1) Short-term risks that might be posed to the community during implementation of an alternative; (2) Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures; (3) Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and (4) Time until protection is achieved.

10.5.1 White King Mine Stockpile Alternatives

Alternative SP-2 has the greatest short-term effectiveness because there is minimal adverse impact to the community, workers and the environment during implementation. Alternative SP-2 also requires the shortest time (one month) to implement. All other alternatives have less short-term effectiveness than Alternative SP-2 because they require cover material to be transported from off-site and would take more time to implement. Alternative SP-3a requires one 5.5-month construction season to implement while Alternatives SP-3b, SP-4a and SP-4c require two 5.5-month construction seasons to implement. Alternative SP-3b requires 62,000 cubic yards (5,200 trucks) of off-site cover material as compared to 86,000 cubic yards (7,200 trucks) of off-site cover material required by Alternative SP-3a. Alternative SP-3b involves the additional excavation and placement of 230,000 cubic yards of material. These alternatives would pose the greatest potential risk to workers during regrading and hauling and have a potential for run-off to impact Augur Creek during construction. Short term risks and impacts, if any, from these alternatives can be mitigated or prevented through monitoring and protective measures. Alternatives SP-4a and SP-4d would require more time to implement because they require excavation of 980,000 cubic yards of stockpile material and placement within the White King Mine pit. Alternative SP-5 offers the least short-term effectiveness because it involves the most potential risk to workers. It would also result in a greater impact to the environment as approximately 20 acres of timber would be removed at the new disposal location. Approximately 980,000 cubic yards of stockpile material would have to be excavated and moved up the hillside to the new disposal cell location. Blasting (640,000 cubic yards) and excavation (340,000 cubic yards) of basalt would likely be needed to construct the cell and then the 980,000 cubic yards of basalt would have to be moved and placed in the White King Mine pit. Approximately 35,000 cubic yards (2,900 trucks) of off-site material would be needed. This alternative would require three 5.5 month construction seasons, which is the longest of all the stockpile alternatives.

10.5.2 White King Pond Alternatives

WKPW-2 has minimal impacts because it involves institutional controls only. Alternative WKPW-3 has some short-term impacts compared to WKPW-2 due to the risk to workers from handling and applying hydrated lime and the implementation time is slightly longer. Alternatives WKPW-4, WKPW-5a, and WKPW-6a have more potential short-term impacts on workers and the environment than Alternatives WKPW-3, WKPW-5b, and WKPW-6b because of potential risk to workers during construction and operation of a 300-acre land application system as compared to a surface water discharge system.

10.5.3 Lucky Lass Mine Stockpile Alternatives

Alternative LL-2 would provide the greatest degree of short-term effectiveness and would have no impacts on the community, no health effects to workers, no impacts to the environment, and will require the shortest time period to implement. Alternatives LL-3 and LL-4 would provide the least degree of short-term effectiveness. Although there would be no impacts to the community, Alternative LL-4 would have the greatest impact to the environment and to workers during construction because it would require excavation and moving approximately 260,000 cubic yards of stockpile material to the “off-mine” location. Erosion control measures, dust control, and proper health and safety protocols can mitigate these impacts. In addition, LL-4 requires the longest time period to implement, which is due to the time it would take to construct a new disposal cell.

10.6 IMPLEMENTABILITY

The implementability of the alternatives was assessed by considering, as appropriate, the following factors: (1) Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy; (2) Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions); (3) Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and availability of prospective technologies.

10.6.1 White King Mine Stockpile Alternatives

Alternatives SP-3a and SP-3b do not pose significant difficulties to implement. Both alternatives require regrading and hauling of stockpile material, and placement of a cover. Alternative SP-3b involves the movement of a larger volume of overburden material within the Mines site; however, Alternative SP-3a would require the transport of an extra 24,000 cubic yards of off-site cover material and an extra 200 truck trips. The regrading of stockpiles is implementable with conventional construction equipment. Coordination and approval from the USFS would be required to construct haul roads or for access control. The fence (or barrier) building component of Alternative SP-2 is easy to implement based on availability of services; however, the land use restrictions pose more difficulty in terms of coordination and implementation. Coordination with USFS and private land owners will be required for land use and physical restrictions but are not expected to pose any difficulties. Alternatives SP-4a, and SP-4d would be more difficult to implement than Alternatives SP-3a, and SP-3b. Alternatives SP-4a and SP-4d require excavation and removal of the stockpiles (980,000 cubic yards) to the pit and placement of a soil cover. Placement of material in the pit would pose some difficulties in implementation because of muddy conditions in the pond after dewatering. Alternative SP-4a is slightly easier to implement than Alternative SP-4d because Alternative SP-4d requires additional construction of a permeable limestone treatment.

Alternative SP-5 is the most difficult to implement because it requires excavation of 980,000 cubic yards of stockpile material and moving the stockpiles up the hill to a new disposal location. Blasting and excavation of basalt would likely be needed. The blasted/excavated basalt would have to be moved and placed in the White King Mine pit. This alternative would also require implementing the selected WKPW alternative. Implementing this alternative is expected to be the most difficult in terms of administrative feasibility. Coordination and approval from USFS would be needed to construct a new disposal cell, clear timber resources and construct haul roads or obtain approval for access control. It is expected that there would be more administrative requirements in constructing a new disposal cell in an "off-mine" location as compared to consolidating the stockpiles at the protore pile or within the White King pit.

10.6.2 White King Pond Alternatives

Alternative WKPW-2 can be implemented to limit use of the White King pond water. The ability to monitor the effectiveness may be hindered by the remote location of the Mines site and because the Mines site is not accessible during the winter months. The services and materials required to construct the monitoring wells should be available. The administrative feasibility of implementing the land use restrictions may be difficult. This may require coordination within the Forest Service and with local government offices to ensure that the restrictions are effectively implemented, maintained and monitored.

Alternative WKPW-3 can be easily implemented (and has been already demonstrated) to neutralize the White King pond water. The neutralization process is technically feasible because the liming process is a well-established practice and liming materials and equipment are available and can be transported to the Mines site. Periodic neutralization may be needed. However, preliminary results of the 1998 Neutralization Treatability Study confirmed that neutralization of the pond is relatively easy to implement. The administration feasibility of implementing this alternative would not be difficult.

Alternatives WKPW-4, 5a, and 6a can each be implemented to dewater the White King pond and apply the water to the land. Appropriate equipment to handle the high pump discharge pressures and potentially high suspended solids at the bottom of the pit should be available. Additionally, the irrigation system, including the booster pumps for differences in terrain elevation, should also be available. Land application of the water is administratively feasible given that a land application permit from ODEQ is not required under CERCLA. Substantive requirements of the permit would be handled as ARARs. Alternatives WKPW-5b/WKPW-6b are technically feasible regarding ex-situ treatment and surface water discharge structures. Materials and services for the ex-situ treatment system are readily available.

Alternatives WKPW-5b and 6b can each be implemented to dewater the White King pond and discharge the water to Augur Creek. Surface water discharge is administratively feasible given that a permit from ODEQ is not required under CERCLA. Substantive requirements of the permit would be handled as ARARs. If additional treatment is deemed necessary, a treatability study would be needed or a variance from the standard may be necessary. Preliminary results from the 1998 Neutralization Treatability Study indicate that surface water discharge standards can be met.

10.6.3 Lucky Lass Mine Stockpile Alternatives

Alternative LL-2 can be implemented to prevent access to the Lucky Lass Mine stockpiles and to limit land use. Preventing access by constructing a barrier, posting warning signs, etc., should be technically feasible. However, the ability to monitor the effectiveness may be hindered by the remote location of the Mines site and because the Mines site is not accessible during the winter months. The services and materials required to construct the fence, etc., should be available. The administrative feasibility of implementing the land use restrictions may be difficult. This may require coordination within the Forest Service and with local government offices to ensure that the restrictions are effectively implemented, maintained, and monitored. However, these restrictions are not unusual.

Alternative LL-3 involves relatively small excavation and placement of material (3,000 cubic yards) with the White King stockpile materials and would be relatively easy to implement. The services and materials are readily available. The administrative feasibility of implementing the land use restrictions may be difficult as described under Alternative LL-2.

Alternative LL-4 is technically feasible, and materials and services are available for the excavation and movement of the stockpile material (263,000 cu. yd.). Under Alternative LL-4, the material would be placed in an "off-mine" location which could have significant administrative difficulties associated with permitting and approvals by the USFS. Administrative feasibility would be difficult for the same reasons as Alternative SP-5.

10.7 COST

This criterion includes estimated capital and operation and maintenance costs as well as present worth costs. Cost estimates are expected to be accurate within a range of +50 to -30 percent.

Table 10-1 presents a comparative summary of the total capital costs, the present worth of O&M cost, and the total present worth costs for all the alternatives as presented in the FS.

A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." (CFR §300.430(f)(1)(ii)(D)). This is accomplished by evaluating the "overall effectiveness"of those alternatives that satisfied the threshold criteria (*i.e.*, were both protective of human health and the environment and ARAR-compliant).

10.7.1 White King Mine Stockpile Alternatives

Alternative SP-2 has the lowest cost (at a total present worth cost of $956,000). Alternative SP-5 has the greatest cost at a total present worth of $26,840,000. Alternatives SP-3a and SP-3b fall within a $5,000,000 to $8,000,000 range while Alternatives SP-4a and SP-4d fall within an $11,000,000 to 12,000,000 range. Compared to all other alternatives, Alternative SP-5 is the least cost effective when comparing costs proportionate to overall effectiveness.

Under ODEQ's State statutes, remedies must also demonstrate costs are reasonable by showing costs are proportioned to benefits. Alternative 3b would cost approximately $1.8 million more than

Alternative 3a. Alternatives 4 and 5 would cost up to several times the costs of Alternative 3a or 3b.

With regards to the Stockpile Alternatives only SP-3b and SP-5 met the threshold criteria to remove overburden from the flood plain and allow compliance with State regulations. Between these two alternatives SP-3b had the lowest cost at approximately $6,625,000. Alternative SP-5 has the greatest cost at a total present worth of $26,840,000. Alternative SP-5 is the least cost effective when comparing costs in proportion to overall effectiveness.

10.7.2 White King Pond Alternatives

Alternative WKPW-2 has the lowest cost at a total present worth cost of $281,000, while Alternative WKPW-6a has the greatest cost at a total present worth cost of $1,731,000. As discussed in Section 9 of this ROD, implementation of White King pond Alternatives WKPW-4, WKPW-5a, WKPW-5b, WKPW-6a, and WKPW-6b are linked to various stockpile alternatives. Depending on which stockpile alternative is selected, the cost of the White King pond alternatives must be added to the cost of the stockpile remedy to evaluate cost-effectiveness. Because Alternatives SP-4a, SP-4d and SP-5 are less cost effective than the other alternatives, White King Pond Alternatives WKPW-4, WKPW-5a, WKPW-5b, WKPW-6a, and WKPW-6b would not be as cost effective as WKPW-3.

10.7.3 Lucky Lass Mine Stockpile Alternatives

Alternative LL-2 has the lowest cost at a total present worth cost of $355,000. Alternative LL-3 has the next lowest cost with a total present worth cost of $535,000. Alternative LL-4 is the most expensive with a total present worth cost of $2,768,000.

The cost effectiveness of Alternative LL-4 is also dependent upon selection of a remedy involving offsite disposal of White King stockpiles. The addition of costs attributable to those White King options along with costs for Alternative LL-4 make it even less cost effective than the other alternatives.

10.8 STATE ACCEPTANCE/SUPPORT AGENCY ACCEPTANCE

The USFS, DEQ, and OOE have been involved with the development and review of the RI, FS, proposed plan and ROD. These agencies concur with the selected remedy in this ROD. The State does not support selection of Alternatives SP-3a and SP-4a for the reasons outlined in Section 12.1.1.

10.9 COMMUNITY ACCEPTANCE.

This criterion evaluates whether the local community agrees with EPA's analyses and preferred alternative. Community members expressed support for Alternatives SP-3b, WKPW-3, and LL-3.

EPA, with input from the State of Oregon, and USFS have carefully considered all comments submitted during the public comment period and taken them into account during the selection of the remedy for the Mines site. EPA's response to comments received during the public comment period are included in the attached Responsiveness Summary (Appendix A).

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SECTION 11

PRINCIPAL THREAT WASTE

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practical. A principal threat concept is applied to the characterization of "source material" at a Superfund site. A source material is material that includes or contains hazardous substances, pollutants or contaminants that act a reservoir for migration of contaminant to ground water, surface water or air, or acts as a source for direct exposure. EPA has defined a principal threat wastes as those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur.

The stockpiles at the Mines site are considered to be relatively non-mobile with low toxicity which can be reliably contained. A treatability study for the leachability of stockpiled material was conducted during the RI/FS. The results indicated that the stockpile soils exhibited little tendency, if any, to release toxic constituents in toxic amounts or at levels which could impact water quality. (See Section 5.3.1.5 for a discussion of the groundwater results adjacent to and beneath the stockpiles.)

ODEQ has a "hotspot" provision under OAR 340-122-085 (implementing rules of ORS 465.200-900) that is similar to EPA's "principal threat" concept. For purposes of this requirement, a "hot spot" is defined as: 1) for ground or surface water, hazardous substances having a significant adverse effect on existing or reasonably likely future beneficial uses of water or waters to which the hazardous substances would be reasonably likely to migrate and for which treatment is reasonably likely to restore or protect such beneficial uses within a reasonable time, and 2) for other media, the extent to which hazardous substances exceeding background concentrations present an excess risk of cancer of 1×10^{-4}, a hazard quotient of 10 for human exposure, or a toxicity quotient of 10 for ecological receptors (OAR 340-122-115(35)).

ODEQ cleanup rules (OAR 340-122) require that all remedies treat "hot spots" of contamination to the extent feasible. The feasibility evaluation under the ODEQ cleanup rules is based on the five remedy selection factors which include cost reasonableness. The FS did consider treatment of "hot-spots" in soil (there are no hot spots in other media). It was estimated that approximately 330,000 cubic yards of stockpile material would exceed the ODEQ arsenic or radium-226 1×10^{-4} cancer risk level and background concentrations. This "hot-spot" material consists of both sand and gravel material and clay-like material. Solidification/stabilization of this material was considered but would not be effective on the clay-like material. The sand-gravel portion (230,000 cubic yards) was evaluated for treatment but there did not appear to be an incremental advantage in treating the "hot-spots" and it is not certain that solidification/stabilization would be able to provide the additional benefit of reducing the leaching potential for these materials. Therefore, for these reasons, treatment of this "hot spot" soil was not retained because of effectiveness and implementability concerns, and very high incremental cost over other alternatives which offered similar effectiveness and protection of human health and the environment. Finally, it was determined that after completion of any of the other options retained through the detailed evaluation in the FS, there would be no potential exposure to "hot spot" materials which would be covered or restricted.

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SECTION 12

THE SELECTED REMEDY

The selected remedy is Alternative SP-3b for the White King Stockpiles, Alternative LL-3 for the Lucky Lass stockpile, and WKPW-3 for the White King pond. These alternatives are discussed more fully below. The selected remedy meets the requirements of the two mandatory threshold criteria: protection of human health and the environment, and compliance with ARARs, while providing the best balance of benefits and tradeoffs among the five balancing criteria: long-term effectiveness, short-term effectiveness, implementability, reduction in toxicity, mobility and volume through treatment, and cost. The selected remedy also provides for meeting the remedial action objectives and remediation goals presented in Section 8.

12.1 SUMMARY OF THE RATIONALE FOR THE SELECTED REMEDY

The key factors upon which the remedy decision is based are presented below along with a description of how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria.

12.1.1 White King Stockpiles

The selected remedy for the White King Stockpiles is consolidation of the two stockpiles, including portions of Augur Creek impacted by erosion from the stockpiles, and "off-pile" and haul road material, at the location of the mine waste repository (Alternative SP-3b). (As discussed separately in Section 12.2.3 soils from the Lucky Lass stockpile will also be consolidated into the White King stockpile.)

Alternative SP-3b will be protective of human health and the environment and meet all ARARs. Compliance with the State of Oregon's rules for the disposal of radioactive material was one of the main factors upon which the remedy decision is based. Moving the protore stockpile out of the Augur Creek floodplain will insure that the remedy meets the State floodplain and erosion standards. Several other factors that led to selecting this alternative are as follows:

- Alternative SP-3b will have high long-term effectiveness and permanence. The 7.5 feet of recompacted clay and 2 feet of soil on the cover will provide an additional effective thickness not found in Alternative SP-3a. The clay/soil cover will reduce infiltration, contaminant migration from erosion, and provide adequate freeze thaw protection for the underlying stockpile material. The 2 feet of soil cover will also help promote native vegetation. Because the consolidated stockpile is isolated below the 7.5 foot clay/2 foot soil cover, the potential for direct exposure and inadvertent human or animal contact is also reduced.

- Consolidation of the two stockpiles will reduce the total area to be covered as compared to Alternative SP-3a. A single cover in one location with a smaller surface area will be somewhat easier to maintain and monitor than two separate stockpiles and covers as found in Alternative SP-3a.

- There was little additional long-term effectiveness for the in-pit and off-mine disposal alternatives that would justify the significantly greater costs. In addition, there were a number of technical uncertainties on the potential ground water impacts from the in-pit disposal option, which could not be easily resolved.
- Consolidation will restore a greater portion of Augur Creek/Meadow wetland habitat to pre-mining conditions than covering the two White King stockpiles in-place. This was a potential benefit supported by community members, the State, and Forest Service during the public comment period.

12.1.2 White King Pond

The selected remedy for the White King pond is continued in-situ neutralization (WKPW-3).

Selection of Alternative WKPW-3 was a logical outgrowth from the 1998 neutralization study and selection of SP-3a as the preferred stockpile alternative. WKPW-4 through WKPW-6b involved land application or surface discharge of the pond water. These alternatives would have been implemented in coordination with a selected alternative for the White King stockpiles addressing consolidation/containment of stockpiles or clean or treated fill within the mine pit. As discussed previously, filling in the pond with stockpile material would not meet State of Oregon requirements for disposal of radioactive material and was associated with a number of technical uncertainties which could not be easily resolved. Because SP-5, the only alternative that used clean material to fill the pond, was less cost effective than the other alternatives, White King Pond Alternatives WKPW-4, WKPW-5a, WKPW-5b, WKPW-6a, and WKPW-6b would not be as cost effective as WKPW-3. In addition, the community and USFS expressed a desire to retain the pond as a potential aquatic habitat. The 1998 neutralization study demonstrated that it was possible to raise the pH in the pond through treatment which could allow eventual establishment of a diverse aquatic habitat.

12.1.3 Lucky Lass Stockpile

The selected remedy for the Lucky Lass stockpile is excavation of soils from the stockpile that exceed cleanup goals for arsenic and radium-226 and restoring the excavated area with topsoil (LL-3).

LL-3 was selected because it provided the greatest degree of assurance of long-term effectiveness at a reasonable cost. It also is relatively easy to implement, results in lower residual risk, and it provides for reclamation of the Lucky Lass Mine stockpiles. The remaining stockpile material, presents a much lower level of risk which can be easily managed through institutional controls. Excavation of the entire stockpile, as in LL-4, is not necessary in order to achieve protectiveness.

12.2 DESCRIPTION OF THE SELECTED REMEDY

This section expands on the description of the Selected Remedy for each area at the Mines site from that which was provided in the Description of Alternatives (Section 9). The remedy may change somewhat as a result of the remedial design and construction processes. Any significant changes to the remedy described in the ROD will be documented using a technical memorandum, an ESD, or ROD amendment which would be included in the Administrative Record.

12.2.1 White King Stockpiles

The Selected Remedy for the White King Stockpiles is as follows:

- **Reconfiguration of the Protore Stockpile**

  The protore stockpile will be reconfigured in order to remove stockpile material from the Augur Creek floodplain. It is estimated that approximately 138,000 cubic yards of material will need to be moved. **Figure 12-1** shows a conceptual design of the reconfigured protore stockpile, with the overburden stockpile on top, in relation to the Augur Creek floodplain and other major features at the White King mine. The exact dimensions and elevation of the reconfigured stockpile will be determined during the remedial design and will take into consideration natural features present at the Mines site, the volume of the overburden stockpile, and the location of the Augur Creek floodplain.

- **Consolidation of the Stockpiles**

  The White King overburden stockpile (430,000 cubic yards), off-pile (35,000 cubic yards)(including portions of Augur Creek impacted by erosion from the stockpiles), and haul road material (15,000 cubic yards) will be excavated and relocated on top of the reconfigured protore stockpile. This material will be subsequently covered with regraded "clay-like material" present within the existing stockpiles. "Clay-like material" is a term used to describe stockpile materials that consist of mixtures of clay and larger sized particles that exhibit significant plasticity in the field and low permeability in laboratory tests. The clay-like overburden will be compacted which will help impede potential burrowing animals. Excavation of the overburden stockpile, off-pile, and haul road material will occur during the first construction season. Additional details on the cleanup approach for the excavation of soils is presented below. The remedial design for the consolidated stockpiles (also referred to as the mine waste repository) shall include features to control surface infiltration, surface water runon and runoff and any impacts from upgradient shallow ground water. These features may include but are not limited to the following: a low permeability layer utilizing the maximum thickness of regraded clay-like material over the top of the stockpile; use of natural features or drainage swales to divert surface water and french drains to divert shallow ground water away from the consolidated stockpile; and, to the extent practicable, the final stockpile configuration shall fit into the natural topography. The design shall be developed to accommodate a 500-year 24-hour storm event. **Figure 12-2** shows a conceptual view of proposed design features of the consolidated stockpile. **Figure 12-3** depicts a conceptual cross section of the consolidated stockpile and **Figure 12-4** illustrates several conceptual design features of the consolidated stockpile. The final slopes of the stockpile will be approximately 4 percent on the top and 5:1 on the sides. The final dimensions and elevations of the stockpile will be determined during design.

  Cleanup Approach for Stockpiles, "Off-Pile", and Haul Road Areas

  The low-grade ore and minespoil piles have been sitting at the Mines site for over 40 years and have been subject to wind erosion, oxidation, and leaching. Thus, radioactive materials, and other contaminants may have been spread around the two mines. **Figure 11-5** from the Draft EIS provides the approximate areas and depths of contaminated soil at the White King Mine based on gamma surveys.

(**Figure 11-6** provides a similar figure for the Lucky Lass mine). Information obtained in the RI indicates that in most cases the stockpiles and disturbed areas can be readily identified from the native surface material by their color, texture, and gamma radiation. In order to prevent excavation into naturally occurring mineralized subsurface soil the following approach has been developed:

- The initial cleanup approach for stockpiles, off-pile, Augur Creek, and haul road areas is to remove the chalk-like (referring to color and not consistency) material down to the original organic soil (or sediment in the case of Augur Creek) layer using a "visual approach".
- After "visual" cleanup is completed, confirmatory sampling including gamma screening[7] will be conducted in such a manner as to confirm completeness of visual removal and achievement of the soil excavation levels (See **Table 12-1 page 12-14**), at the level of the organic soil layer. An alternative approach would be to remove the upper six inches of meadow surface, wherever it is in contact with the radioactive materials in the stockpile, off-pile, and haul road areas. In either case clean fill will be added to the surface after soil removal, in order to meet background surface soil concentrations.

The specific clean-up approach will be determined during the Remedial Design and Remedial Action Workplan with consideration being given to localized background for the Mines site. Among the factors which may be considered by EPA in determining the additional amount of material to excavate will be the following: satisfying surface exposure or background requirements, the type of material which is found and whether the material in question is leachable (or has leached) posing a potential source to ground water or surface water, whether the surface readings result in finding subsurface naturally occurring radioactive material, potential damage to meadow soils that further excavation may cause, and State acceptance. A similar approach will be applied to Augur Creek sediment removal. Factors to be considered by EPA in determining sediment removal will be the toxicity of the sediments to aquatic organisms using available sediment criteria, risk to recreational users, and the potential ecological impacts, such as habitat loss or disruption, associated with removal of contaminated sediments. Following excavation of soils and sediments, residual risk will be evaluated in accordance with ODEQ's cleanup law (ORS 465.315, OAR 340-122-040).

[7] Evidence collected during the RI indicates that radioactive contaminants are co-located with other contaminants such as arsenic. An approach to identify and cleanup radiological contaminants, such as radium-226, to background should assure that arsenic and other uranium decay-series radionulcides will also be removed. Gamma surveys may be sufficient for initial verification of cleanup. However, there also may be a need for some representative analytical sampling to confirm the removal of arsenic to background.

- **Stockpile Cover**

In addition to the recompacted clay layer mentioned above a two-foot soil cover will be placed over the mine waste repository. The total area that will require cover material is approximately 25 acres. General cover soil can be borrowed from numerous sources including areas at the Lucky Lass mine (1.5 miles from White King mine), National Forest System lands between the White King mine and Lucky Lass mine (1 mile from White King mine), as well as private sources located 3, 6, and 15 miles from the Mines site. The soil cover shall also include a storm water collection system to reduce the potential for erosion from or pooling of surface water. Final details on the soil cover and stockpile configurations will be developed during the design. Vegetation will be established on the top of the cover consisting of local climax vegetation (i.e., cool season grasses that are dormant in the summer and do not require long-term irrigation). The appropriate vegetation will be determined during the design phase.

- **Inspection & Maintenance**

Inspection and Maintenance (I&M) of the mine waste repository will include inspection and repair of the fences/physical barrier, gates, locks, warning signs, monitoring wells, and maintenance of the 24-inch soil/vegetation cover, and stormwater management system. A minimum of two site inspections will be conducted each year during the late spring and fall. It is conservatively assumed that 5 percent of the total acreage of vegetation and 5 percent of the topsoil volume would be replaced each year.

A draft I&M plan that will be prepared as part of the design which will outline the above activities and quantitatively define how the inspector should identify a "satisfactory area of vegetation." Areas that show signs of erosion or sparse vegetation will be repaired. The surface will be graded and/or filled to match the surrounding grade with topsoil material. The area will be reseeded, mulched, and sufficiently watered to restore the vegetation. Woody shrubs or trees will be identified and removed before deep roots are established.

The cover system will be inspected for areas of significant erosion. To further control erosion in the long term and prevent gully propagation, certain guidelines will be developed during the design. The eroded areas will be backfilled with cover soil and topsoil, and reseeded/mulched. The cover system will also be inspected for signs of settlement and subsidence. Areas showing signs of potential ponding or continued settlement will be backfilled and repaired as described for erosion gullies.

Erosion control devices such as silt fences, hay bales, and/or jute or straw mats will be inspected during the first year following construction completion. Silt fences, hay bales, and/or jute or straw mats will be maintained for a minimum of one year or until a full vegetative layer has been established. Silt fence posts that are no longer secure or vertical will be reinstalled. Damaged fabric will be repaired or replaced with new fabric. Hay bales that are no longer intact or secured to the subgrade will be replaced. If there is evidence that runoff is passing around the hay bales, then the hay bales will be replaced or repositioned, or additional hay bales will be added. Damaged jute or straw mats that are no longer secure will be reinstalled, if necessary, in the event vegetation has not been established.

In addition to the above actions EPA can and will require additional actions if necessary to maintain the protectiveness of the stockpile remedy.

- **Reclamation**

After excavation of the overburden stockpile, portions of the protore stockpile and off-pile and haul road areas, the disturbed areas will be reclaimed/revegetated using a minimum of 3 inches of soil. A significantly thicker layer of soil may be required in certain areas to meet surface soil background levels as previously discussed in the "cleanup approach". The vegetation will consist of local climax vegetation (i.e., cool season grasses that are dormant in the summer and do not require long-term irrigation). The total area requiring reclamation/ revegetation is estimated to be 36 acres. Based on field observations during the RI, meadow areas situated on and downgradient of the stockpiles displayed characteristics (i.e., hydrophylic vegetation, hydric soils, and hydrology) satisfying the criteria for identification of a wetland area as outlined in the 1987 Corps of Engineers Wetland Delineation Manual (ACE, 1987). If there are any potential impacts on the wetlands due to the implementation of the final remedy, the remedial design will need to address these impacts.

- **Monitoring**

Ground water, surface water, and sediment monitoring and evaluation will be conducted as part of the stockpile remedy to: (1) determine the effectiveness of the source control measures in preventing erosion and infiltration, (2) insure that contaminants are not migrating into Augur Creek (via surface runoff or ground water discharge to surface water), (3) further refine background levels and/or establish ground water, surface water, and sediment trends, and (4) insure the remedy remains protective of the potential beneficial use (aquatic habitat and livestock) and meets applicable standards. A monitoring plan shall be submitted, including a quality assurance program plan and a sampling plan, for EPA approval during the remedial design. Monitoring locations, sample frequency and indicator parameters will be defined in the site monitoring plan. The monitoring program will be assessed periodically to determine if it should be supplemented or modified in any way. Additional remedial actions may be required in the event the evaluation of monitoring data show contaminant levels have increased and/or pose a threat to the environment. The following are specific monitoring requirements for Augur Creek and ground water upgradient and downgradient of the mine waste repository.

Augur Creek Sediment and Surface Water Monitoring

Surface water and sediment samples will be collected in Augur Creek both upgradient and downgradient of the consolidated stockpile at a minimum of one time per year. As previously discussed in Section 8.2 surface water in Augur Creek is expected to meet Oregon's State water quality standards (OAR 340-41-925) for the Goose Lake Basin (See Table 8-1) and beneficial uses for the Goose Lake basin. Monitoring shall be conducted in surface water to insure that these standards are being met. Sediment monitoring shall be conducted to establish trends and insure the remedy is protective.

Ground water Monitoring

As with surface water, the discharge of ground water to surface water is expected to meet Oregon's State water quality standards. At a minimum, the monitoring plan shall outline sampling for alluvium and shallow bedrock wells upgradient and downgradient of the mine waste repository[8]. The goal of monitoring is to ensure that the potential beneficial uses of ground water (discharge to surface water) meet Oregon's State water quality standards (OAR 340-41-925) for the Goose Lake Basin (See Table 12-5 page 12-16) at the boundary of the waste management area with Augur Creek and/or to establish a trend toward background concentrations.

- **Institutional Controls**

Land use restrictions will be put in place to limit and manage human exposure to contaminated soil underneath the Mine waste repository cover and underlying groundwater, and any uses that could impact the integrity of the Mine waste cover. **Figure 6-1** shows the boundaries of public and private property at the Mines site. The private property that requires institutional controls is:

Parcel 1, S1/2NE1/4, Section 30, T.37S., R.19E., W.M. This parcel is currently owned by the Coppin Trust (surface estate) and members of the Leehmann and Coppin families (mineral estate)

Because the mine waste repository will be located on both National Forest System Lands and private property, different mechanisms for land use restrictions will be required:

For private property land use restrictions will include proprietary controls such as an equitable servitude and easement (consistent with ODEQ's "Final Guidance for Use of Institutional Controls" (ODEQ, 1998). This is a legal instrument placed in the chain of title that provides access rights to a property for inspection and maintenance and monitoring and restrictions preventing residential use and installation of drinking water wells. This type of control shall be set forth in an EPA and DEQ-approved form running with the land and enforceable by EPA and DEQ against present and future owners of the property. As an informational device the Mines site will be maintained on DEQ's Environmental Cleanup Site Information Database as long as the institutional controls remain in effect. One additional informational device is a deed notice to inform property owners that contamination remains on site. Placement of a deed notice can be made by EPA.

On National Forest System Land, an amendment to the Forest Plan (attached to this ROD) has been made by the Forest Service that prohibits the following uses on 240 acres at the Mines site. These prohibitions apply to most of the Mine Waste repository, all of the Lucky Lass stockpile and a small portion of the White King pond:

Prohibitions

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[8] As discussed in section 5.3.1.5 the perched ground water beneath the protore stockpile had elevated levels of inorganics and radionuclides which pose a human health risk. This remedy employs institutional controls to prohibit use of this ground water for drinking purposes and therefore remediation levels or monitoring are not required for the ground water beneath the consolidated stockpile.

- Residential structures or use
- Drinking water well drilling
- Any permanent structures
- Permanent recreation sites (e.g., campgrounds) and uses (e.g. swimming in White King pond)
- Removal of stockpiled material
- Agricultural Activities
- Any other use that would impact the integrity of the Mine waste repository and Lucky Lass stockpile, including grazing on stockpiles and off-road vehicle use

The area of the Mines site was also withdrawn from mining by the Bureau of Land Management (BLM) on August 9, 1993 to protect the rehabilitation work to be done on the White King and Lucky Lass mine. This withdrawal will expire on August 9, 2013 (20 years) unless the withdrawal is extended. The USFS will request that the BLM continue to maintain a withdrawal of the area of the mine waste repository from mineral entry since this activity could damage the soil cover and the effectiveness of the remedy.

Confirmation that land use restrictions are obeyed whether on private property or National Forest System lands will be monitored visually during the site inspections. During the site inspections, the private property and National Forest System lands within and adjacent to the Mines site will be assessed as to whether the land use restrictions have been violated (e.g., material removed from the repository, construction of housing etc.).

- **Physical Access Restrictions**

Access will be restricted by constructing a fence or other physical barrier surrounding the mine waste repository in order to prevent exposure to and disruption or use of the stockpiles materials. This fence/barrier will also prevent disturbance of the mine waste repository from humans and cattle or medium-to-large animals, which could expose the material to the effects of wind and water erosion. The specific type and size of the fence/barrier will be determined in design. If a fence is selected in design the foundations for the fence posts will extend below the maximum frost penetration depth to prevent damage to the fence from the freeze/thaw cycle during the winter months. A fence should have gates that can be locked at all times. Warning signs will be posted every 200 feet along the fence/barrier stating the hazards, who to contact, and advising people not to remove or disturb any of the stockpiled material. Efforts will be made to reduce the visual impact of the fence/barrier.

12.2.2 White King Pond

The Selected Remedy for the White King Pond is as follows:

- **Stormwater Management**

  A diversion ditch will be constructed around the top of the highwall to collect and direct stormwater and minimize further erosion of the highwall. A stormwater management plan shall be developed during the design which will address surface water runoff, impact of perennial seeps at the base of the highwall, and highwall slope/stability in order to adequately address continued erosion into the pond.

- **Maintenance of the White King pond**

  The pH in the pond water will be increased through periodic addition of pulverized limestone, limestone rock, hydrated lime or other neutralizing agents like soda ash. The state water quality standards for Goose Lake Basis requires a pH range of 7-9. The limestone application rate and frequency is a function of factors such as existing water quality, source of acidification, volume of water, residence time of pond water, limestone application method, and limestone type, purity and particle size. The frequency and rate of liming will be determined during the design.

  In addition to the liming, fertilizer may be added to the pond to stimulate primary biological activity. The biomass that would be produced from the biological activity would settle to the bottom of the pond and begin to develop a cover over the existing sediments. Any additional application volume and frequency of the fertilizer would be determined during the design and remedial action phase and will depend on the monitoring results discussed below.

- **Monitoring/Assessment**

  Monitoring of the pond (water and sediments) and ground water (including surface discharge or seeps along the highwall) will occur at a minimum of one time per year. A monitoring plan including a quality assurance program plan and a sampling plan will be submitted for EPA approval during the remedial design. The overall purpose of the monitoring is to collect information to evaluate the effectiveness of pond neutralization, establish trends, and enable further evaluation of the spatial distribution of contaminants and the risks associated with pond water, seeps, and sediments. Specific objectives include the following: Improve the conceptual site model for the pond; further describe the geochemical processes affecting pond chemistry and aquatic life; further characterize the sources, nature and extent of COCs in sediments, surface water, and seeps, and evaluate the ability to achieve Oregon's State water quality standards (OAR 340-41-925) for the Goose Lake Basin, particularly for pH.

  In addition to the above monitoring, an assessment of the toxicity, bioavailability and bioaccumulation potential, and species exposure to contaminants in pond sediments shall be conducted. This assessment, in conjunction with the above pond monitoring, will provide information on the ecological risks associated with the pond and the feasibility of environmental protection for the proposed beneficial uses (primarily aquatic habitat).

Further evaluation of risks should utilize site-specific factors such as chemical bioavailability and toxicity to benthic and aquatic organisms using tests acceptable to EPA.

The results of each seasons sampling and monitoring data will by reviewed annually by the EPA. The information will be evaluated to determine if the pond neutralization is effective and what risks are associated with pond sediments. If the data verifies the toxicity of pond sediments to benthic or aquatic organisms at the population level which could impact higher trophic levels, additional action such as sediment capping or dredging may be required. This action would be documented in an ESD or ROD amendment.

- **Institutional Controls**

  Land use restrictions will be put in place to prevent residential, recreational, or agriculture uses of the pond. Because the White King pond is located on both National Forest System Lands and private property, different mechanisms for land use restrictions will be required as described above for the White King Stockpiles. The majority of the pond is on private land therefore the predominant mechanism for implementation of these controls will be through proprietary controls such as an equitable servitude and easement (consistent with ODEQ's "Final Guidance for Use of Institutional Controls" (ODEQ, 1998).

- **Access Restrictions**

  Physical restrictions, such as fencing, will be required to prevent exposure to the pond water and sediments. These restrictions may be eliminated in the future depending on the success of neutralization and any actions to address the risks associated with the pond sediments. Warning signs will be posted every 200 feet along the fence stating the hazards, who to contact, and advising people not to swim in the pond.

- **Inspection and Maintenance**

  Site inspections will be conducted at a minimum of twice per year. The inspection and maintenance activities will include inspection and repair of fences, gates, locks, warning signs, and monitoring wells caused by inclement weather or vandalism.

12.2.3 Lucky Lass Stockpile

The Selected Remedy for the Lucky Lass Stockpile is:

- **Soil Excavation**

  All surface soils that exceed the levels shown in **Table 12-5 page 12-16** shall be excavated and placed within the White King mine waste repository:

  Most of these soils have been identified in the Lucky Lass meadow, downhill from the overburden pile and Lucky Lass pit, with the highest uranium activities occurring in the upper 1 to 2 feet of soil. Other soils with elevated radium-226 activity occur on top of the Lucky Lass stockpile as a reddish-black rock, which contrasts with the lower activity chalk-colored overburden. It is estimated that approximately 3,000 cubic yards of soil exceed a cleanup level of 3.6 pCi/g for radium-226 and 38 mg/kg for arsenic. A field screening methodology for identification of these soils, similar to the approach outlined above for the

White King soils, will be developed during the design. The excavated areas will be restored to existing grade including 3 inches of topsoil. The Lucky Lass stockpile material that has been impacted by drainage from the Lucky Lass pond will also be excavated and moved so that there is no further erosion impact from the Lucky Lass pond drainage. The excavated material will be regraded with the Lucky Lass stockpiles and the excavated area will be restored with riprap to reduce erosion. Recontouring of the Lucky Lass Mine overburden stockpile may also be necessary if portions of the stockpile are used as a borrow source for the White King mine waste repository cover. Such activities may include, but are not limited to, regrading the stockpiles to provide slope stability, promote drainage, and control erosion; placement of topsoil; and establishment of vegetation on the stockpile. No future monitoring or inspection and maintenance of the Lucky Lass stockpile will be required.

- **Institutional Controls**

  Because the Lucky Lass mine area is situated entirely on National Forest System land, institutional controls must be implemented through Forest Service mechanisms only. Land use restrictions are required to prevent residential/recreational use at the mine, installation of drinking water wells within the stockpile, and removal of stockpile material. As discussed for the White King stockpile an amendment to the Forest Plan has been made by the Forest Service to prohibit these and other uses. In addition the area of the Lucky Lass Mine has been withdrawn from mining as described for the White King Stockpile remedy. As an informational device the Mines site will be maintained on DEQ's Environmental Cleanup Site Information Database as long as the institutional controls are required.

- **Access Restrictions**

  Short-term access restrictions will include physical restrictions (e.g., fencing), warning signs, and safety measures until completion of the remedial action.

12.4 PERMITS

CERCLA Section 121(e)(1) states that no Federal, State or local permit shall be required for the portion of any removal or remedial action conducted entirely "on-site" where such remedial action is selected and carried out in compliance with Section 121. The term "on-site" is clarified in the NCP, 40 CFR 300.400(e), which states that on-site means the aerial extent of contamination and all suitable areas in very close proximity necessary for implementation of the response action. EPA has determined that the land areas adjacent to the White King and Lucky Lass Stockpiles to be used for consolidation and/or recontouring of the stockpiled material are necessary for implementation of the remedy and considered on-site for purposes of CERCLA Section 121(e)(1).

12.5 SUMMARY OF THE ESTIMATED REMEDY COSTS

The Total Present Worth Cost of the Selected Remedy is approximately $7,900,376[9] based on a present worth discount rate of 7% and 30-year O&M. This value is for the combined costs for the White King Stockpile Alternative SP-3b, White King Pond Alternative WKPW-3, and Lucky Lass Stockpile Alternative LL-3. These costs are summarized in **Tables 11-1 through 11-3**.

Due to changes made in Alternative SP-3b during the remedy selection process the cost estimate in the FS (and presented in Section 10 of this ROD) has been modified to include the additional costs for excavation of portions of the protore stockpile and the costs for an additional 12-inch soil cover. In addition to these changes, EPA reduced the contingency costs for this alternative in the FS estimates from 25% to 10%. This decision was based on input from Jacobs Engineering under contract to the Forest Service and the Corps of Engineers who felt that a 25% contingency was too high given the relatively few unknowns associated with this project. This resulted in a significant reduction in the cost estimate that was shown in the FS for a similar alternative. On the other hand the cost associated with the sediment monitoring was not estimated in the FS and has not been included in the total remedy cost. Given the significant unknowns surrounding the nature and extent of this monitoring no attempt was made to estimate these costs at this time.

The cost summary provided is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, and ESD, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost.

12.6 EXPECTED OUTCOMES OF THE SELECTED REMEDY

The purpose of this response action is to control risks posed by direct contact with contaminated soil, ground water, and sediments and to minimize migration of contaminants to these media. The results of the baseline risk assessment indicate that existing conditions at the Mines site pose an excess lifetime cancer risk of 3×10^{-4} to a current worker exposed to radionuclides in soil. Risks to workers from arsenic in soils was 6×10^{-5} . Non-cancer risks were also elevated (hazard index of 4) for current child recreational users primarily from ingestion of arsenic in soils. For potential future residents the chemical and radionuclide cancer and non-cancer risks were much higher (cancer risks up to 5×10^{-1} and non-cancer hazard indexes up to 5,000) due to exposure to soil and shallow ground water.

The source control measures of consolidation and cover of the White King stockpiles, off-pile areas, and haul road and portions of the Lucky Lass stockpile will reduce the pathway of exposure for human and ecological receptors which will reduce the potential risks to correspond with an excess lifetime cancer risk of 1×10^{-6} or a hazard index of 1. It will also reduce the potential migration of contaminants into Augur Creek surface water, sediments and ground water. Monitoring of surface water, sediment, and ground water will be conducted to verify that contaminants are not migrating and ensure the beneficial use of these resources. Implementation

[9] This number is based on a combination of revised costs for Alternatives SP-3b as discussed in section 12.7, Cost for WKPW-3, and Costs for Lucky Lass LL-3.

of the remedy should be completed within 3 years and allow return of the Mine site (with the exception of the mine waste repository and pond) to the anticipated future use of recreation, grazing, and timber production. Riparian habitat in the meadow will also be restored. Short-term impacts during the period of implementation are minimal and do not persist throughout the entire year due to snowfall and limited access to the Mines site.

The baseline ecological risk assessment predicted adverse impact to aquatic invertebrates exposed to non-radionuclide contaminants in the White King pond sediments. The greatest risks were associated with the arsenic in sediments (HI of 33). Historically very little aquatic life has inhabited the White King pond. This is probably due to a number of factors including low pH and elevated sediment arsenic levels. Increasing the pH in the White King pond and further evaluation of the sediments will help to determine what future beneficial uses of the pond are achievable. If the data verifies that sediments pose an unacceptable risk to aquatic organisms at the population level which could impact higher trophic levels, additional action such as sediment capping or dredging may be required. This action would be documented in an ESD or ROD amendment.

12.6.1 Remediation Levels

Numerical cleanup levels have been established to address the primary risk drivers and the RAOs discussed in Section 8.0. These values will be used to guide soil excavation and ensure that the source control measures being taken are effective in preventing migration of contaminants into other media. Due to the natural mineralization in the area of the site preliminary background levels are higher than either risk based levels or applicable standards, and are therefore the basis for most of the cleanup levels discussed below. **Further refinement of all media background values will be conducted as part of the remedial design and remedial action.**

White King Stockpile

For the Mines site stockpiles and soils EPA used ODEQ's cleanup law (ORS 465.315 and implementing regulations at OAR 340-122), which establishes standards for cleanup based on acceptable risk levels or background concentration, whichever is higher. At the White King Mine, background levels are higher than the protective levels, due to the natural mineralization in the area, and therefore were used to establish excavation levels. EPA and DEQ policy is to remediate to background, regardless of the risk from exposure to background concentration. Based upon EPA's determined subsurface background at White King the remediation levels shown in Table 12-1 apply to excavation into the surface and subsurface. Clean fill will be added to the surface or excavation after removal of the stockpiles, in order to meet surface soil background concentrations. Surface soil background levels will be established during the remedial design.

Table 12-1 White King Soil Remediation Levels

Area of Site	Chemical	Remediation Level	Basis for Remediation Level
White King Soils	Arsenic	442 mg/kg	Background (95% UTL lognormal subsurface soils - under and near pile locations omitted)
	Radium-226	6.8 pCi/g	Background (95% UTL normal subsurface soils - under and near pile locations omitted)

Because arsenic is an intrinsic component of mineralization at the White King mine, cleanup for radium-226 to background will assure that arsenic, thorium-230 and uranium-234 and -238 also will be removed.

White King Pond Water

The remediation level for arsenic, the primary COC in the pond water, is shown in Table 12-2. Remediation levels would typically be based on surface water quality standards or pond surface water background values, whichever is less stringent. Since the pond was created by mining activities, a background value, as that term is used by EPA, is not available for the pond. Since the pond water is primarily derived from ground water the discharge from ground water to surface water should meet surface water background concentrations since background is higher than the applicable standard or protective level. Therefore, the value shown below is based on the Augur Creek surface water background levels. A remediation level for pH has also been established to guide the neutralization actions being taken on the pond. This value is based on the goal of meeting Oregon's State water quality standards (OAR 340-41-925). Further monitoring and evaluation of the pond during the remedial action will determine the ability to meet this standard.

Table 12-2 White King Pond Water Remediation Levels

Area of Site	Chemical or Parameter	Remediation Goal	Basis for Remediation Goal
White King Pond	Arsenic	0.033mg/L[a]	95% UTL Background[b]
	pH	7-9	Goose Lake Basin Criteria OAR 340-41-925(2)(d)

[a] Based on total recoverable concentrations in water

[b] 95% UTL normal distribution upgradient of White King pond (value may be elevated due to an outlier)

White King Pond Sediment

As a result of limited information on the arsenic concentrations in sediment, and the unknowns associated with long term pond neutralization, numerical cleanup goals for sediment have not yet been established. After a period of investigation and evaluation described in Section 12.2 remediation goals will be selected that will be protective of the beneficial use.

Augur Creek Surface Water

Active remediation of surface water is not required in Augur Creek in order to achieve protection of human health and the environment. Monitoring of surface water will be conducted to ensure the stockpile remedy is effective and ensure that contaminants are not migrating The remediation levels for arsenic in surface water are based on the Augur Creek background concentration developed during the remedial investigation. By selecting a background level as a goal it is in compliance with the state water quality standards and the state environmental cleanup law. Background is provided for under 340-041-925 (3) of the state water quality rule and under OAR 340-122-040 the state cleanup rules.

Table 12-3 Augur Creek Surface Water Remediation Levels			
Area of Site	**Chemical or Parameter**	**Remediation Level**	**Basis for Remediation Level**
Augur Creek Surface Water	Arsenic	0.033mg/L[a]	95% UTL Background[b]

[a] Based on total recoverable concentrations in water

[b] 95% UTL normal distribution upgradient of White King pond (value may be elevated due to an outlier)

Augur Creek Sediment

Some portions of Augur Creek, particularly those adjacent to the White King stockpiles, contain elevated levels of arsenic in sediment from stockpile erosion. The maximum observed background concentration upstream of the White King mine was determined to be 4.2 mg/kg. The lowest effect level for aquatic life, based on the Ontario Sediment Quality Standard, is 6 mg/kg. Since this value is less stringent than background it was selected as the cleanup level for these areas. In the case of Manganese the background value of 1610 mg/kg was less stringent than a protective level of 460 mg/kg (HI=1) and therefore background was selected as the remediation level. A visual cleanup approach as described above for the stockpile soils will be utilized to the maximum extent practicable, followed by verification sampling.

Table 12-4 Augur Creek Sediment Remediation Levels			
Area of Site	**Chemical or Parameter**	**Remediation Level**	**Basis for Remediation Level**
Augur Creek Sediment	Arsenic	6 mg/kg (dry weight)	Lowest Effect Level Ontario Sediment Quality Guidelines
	Manganese	1610 mg/kg	Background Highest Upgradient Concentration

Ground water (White King & Lucky Lass)

Active remediation of ground water is not required at the Mines site in order to achieve protection of human health. Institutional controls are being used to restrict use of ground water beneath the stockpiles. (The concentration of arsenic in all downgradient wells are below MCLs). Discharge of groundwater to surface water is the State designated beneficial use. (Under the NCP ground water would be designated as Class II(b). Eventually ground water at the edge of the waste management area should be returned to drinking water standards (the MCL for Arsenic is currently 50µg/l) or background, whichever is less stringent.) In order to protect the aquatic habitat of Augur Creek, the discharge from ground water to surface water should meet background concentrations since background is higher than the applicable standard or protective level. A potential risk was also identified for radon in ground water. Again the area background values are elevated and the basis for the remediation level. (The current proposed MCL for a community water system is 300 piC/L). Monitoring of ground water will be conducted to insure that contaminants are not migrating and insure protectiveness of the designated beneficial use of ground water.

Table 12-5 White King/Lucky Lass Mine Ground water

Area of Site	Chemical or Parameter	Remediation Level	Basis for Remediation Level
Ground water at Edge of Waste Management Area	Arsenic	0.033mg/L[a]	95% UTL Background[b] for Surface Water
	Radon	704pCi/L	95% UTL Background for Ground water[c]

[a] Based on dissolved concententrations in water

[b] 95% UTL normal distribution upgradient of White King pond (value may be elevated due to an outlier)

[c] Value derived from 14 "background" wells identified in the RI

Lucky Lass Stockpile

As with the White King soils EPA used ODEQ's cleanup law (ORS 465.315 and implementing regulations at OAR 430-122), for establishing standards for cleanup based on acceptable risk levels or background concentration. At the Lucky Lass Mine, the cleanup goals are lower that at the White King Mine due to differences in local background levels. The remediation goal for arsenic is 38 mg/kg based on recreational use (the most likely exposure scenario). The radium-226 cleanup level is 3.6 pCi/g, again based on background levels. The soil cleanup process will begin with gamma screening to identify areas with elevated Radionuclides followed by excavation using a visual criteria as described for the White King stockpile soils. Following soil excavation confirmation sampling and gamma screening will be conducted to verify cleanup.

Table 12-6 Lucky Lass Soil Remediation Levels

Area of Site	Chemical	Remediation Level	Basis for Remediation Level
Lucky Lass Soils	Arsenic	38 mg/kg	$1x10^{-6}$ Protection for Recreational User ORS 465.315
	Radium-226	3.6 pCi/g	Background - 95% UTL normal distribution subsurface soils (without meadow locations)

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SECTION 13

STATUTORY DETERMINATIONS

Under CERCLA §121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with applicable or relevant and appropriate requirements (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the selected remedy meets these statutory requirements.

13.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The selected remedy, Containment and Consolidation of the White King Stockpiles (SP-3b), Pond Water Neutralization (WKPW-3), and removal of soils exceeding remediation goals at Lucky Lass (LL-3), will protect human health and the environment by:

- Preventing direct contact, including ingestion, dermal contact and inhalation of soils containing COCs above health-based levels
- Restricting access to the contaminated soils through physical and institutional controls
- Neutralizing the acidic water in the White King pond and restricting access to the pond until the risks from pond sediments are more fully evaluated
- Consolidating and covering of contaminated soils to reduce infiltration of COCs into ground water

There are no short-term threats associated with the selected remedy that cannot be readily controlled. In addition, no adverse cross-media impacts are expected from the selected remedy.

Implementation of the selected remedy is not expected to pose unacceptable short-term risks or significant cross-media impacts.

13.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy for the Mines site will comply with Federal and State ARARs that have been identified. No waiver of any ARAR is being sought or involved for the selected remedy. Where a State ARAR is equivalent or more stringent that a corresponding Federal ARAR, only the State ARAR is identified. The ARARs for the Mines site are identified below.

Applicable or Relevant and Appropriate Requirements (ARARs)

CERCLA remedial action is required to comply with applicable or relevant and appropriate requirements (ARARs), unless an ARAR is waived. ARARs for cleanup of the Mines site include statutory and regulatory requirements promulgated by the State of Oregon that address the disposal of radioactive material including uranium mine overburden. Also see Section 10.2.1 for a discussion of this ARAR. These rules require that radioactive material not be located in: certain specified locations which affect some of the stockpiles and the placement of the mine waste repository at the Mines site. The rules include a pathway exemption set forth in OAR 345-050-0035, which exempts certain material from the rules. The Oregon Office of Energy, the agency charged with administering these laws, determined that the floodplain and erosion standards apply to the overburden piles because the gamma pathway set forth in OAR 3450-50-0035 is exceeded. OOE has determined that concentrations of radioactive material in the overburden and protore stockpiles at the Mines site exceed the pathway exemption and therefore are subject to the requirements of this rule. For such disposal, a site is not suitable if it is located in: an area subject to surface water erosion over the projected life of the facility considering historical erosion, ancient shorelines, stream beds and cutting due to floods; a 500-year floodplain of a river, stream or creek considering potential erosion effects; an active fault zone; an area of ancient, recent or active mass movement; an area subject to volcanic damage.

The selected remedy will also comply with the following ARARs:

Federal Endangered Species Act of 1973 (16 USC 1531 et seq., 50 CFR Part 200, 402). This regulation is applicable to any action authorized, funded, or carried out by any Federal agency that could jeopardize the continued existence of any listed species or result in the destruction or adverse modification of habitat of such species. The listed and proposed endangered and threatened species that may occur within the area of the Mines site is the bald eagle, Canada Lynx, and Modoc Sucker. A biological evaluation completed by the Forest Service on 6/15/01 determined no impact or environmental effects from the project on habitat, individuals, a population, or listed or sensitive Therefore EPA has determined the implementation of the selected remedy is not likely to affect the listed species or their designated critical habitat.

Oregon Revised Statute (ORS) Chapter 469.375. (Required Findings for Radioactive Waste Disposal Facility). Under this statutory provision, the Oregon Energy Facility Siting Council (EFSC) shall not issue a site certificate for a waste disposal facility for uranium mine overburden unless certain findings are made. Although a site certificate issued by the EFSC is not required at this site pursuant to CERCLA Section 121(e)(1), portions of this requirement are relevant and appropriate. The remedial action will comply with this requirement by not locating the mine waste repository in an area determined to be potentially subject to river or creek erosion within the lifetime of the facility.

Oregon Administrative Rules (OAR) Chapter 345, Division 50 (Radioactive Waste Materials), Section 60 (Site Suitability). These rules are applicable and govern disposal of radioactive material, including uranium mine overburden. For such disposal, a site is not suitable if it is located in: an area subject to surface water erosion over the projected life of the facility considering historical erosion, ancient shorelines, stream beds and cutting due to floods; a 500-year floodplain of a river, stream or creek considering potential erosion effects; an active fault zone; an area of ancient, recent or active mass movement; an area subject to volcanic damage. The remedial action will satisfy this requirement because the mine waste repository will not be located in any of these areas. The rules also include a pathway exemption set forth in OAR 345-050-0035, which exempts certain material from the rules however, the Oregon Office of Energy, the agency charged with administering these laws, determined that the concentrations of radioactive material in the stockpiles at the White King mine exceed the gamma pathway set forth in OAR 3450-50-0035. OOE made this determination based on radium-226 concentrations sampled in the stockpiles (OOE's June 21, 2000 letter sets forth the reports of sampling data). OOE compared these concentrations to levels seen at other sites, and concluded that gamma radiation at the White King overburden and protore stockpiles would result in exposures exceeding 500 millirem per year. Because the exemption does not apply, the remedy will comply with these requirements.

Water Pollution Control Laws (ORS Chapter 468B) and Oregon Stormwater Standards (ORS Chapter 468B.025). Although the administrative permitting requirements of this provision are not applicable to the Mines site, the substantive stormwater protection requirements are relevant and appropriate. The 468 requirements address effluent standards, substantive permit requirements for discharges to U.S. waters, and minimum Federal water quality criteria. The remedy will meet these requirements by consolidating the stockpiles with a cover and native vegetation, and treatment of the White King pond water. Monitoring will be conducted on surface water to ensure the remedy meets these requirements. The 468B requirements address any construction activity that disturbs more than 5 acres. Although a permit is not required at the Mines site pursuant to CERCLA Section 121(e)(1), the substantive provisions of Oregon's NPDES general permit 122-E will apply. The remedial action will meet these requirements through preparation of an erosion and sediment control plan during the design. This plan will use best management practices to prevent discharge of significant amounts of sediment to surface waters in order to comply with water quality standards in OAR 340-41.

Clean Air Act, 42 U.S.C. §§ 7401 et seq., (CAA), National Ambient Air Quality Standards (NAAQS) 40 CFR. Part 50; Oregon implements the Federal Clean Air Act requirements and ambient air standards. These regulations are applicable for control of dust particles emitted into the air during remediation construction activities. The selected remedy will meet these requirements by using dust control measures while excavating the stockpiles.

Oregon Environmental Cleanup Law, Oregon Revised Statute (ORS) Chapter 465.315; OAR Chapter 340 Division 122 (Hazardous Substance Remedial Action Rules). These rules are applicable for the establishment of cleanup levels and selection of remedial actions. OAR 340-122-040(2) requires that hazardous substance remedial actions achieve one of four standards: a)acceptable risk levels, b) generic soil numeric cleanup levels, c) remedy-specific cleanup levels provided by ODEQ as part of an approved generic remedy, or d) background levels in areas where hazardous substances occur naturally. The risk based and background levels are applicable to the Mines site.

OAR 340-122-115 defines the following maximum acceptable risk levels:

- 1×10^{-6} for individual carcinogens
- 1×10^{-5} for multiple carcinogens, and
- a Hazard Index of 1.0 for noncarcinogens

These acceptable risk levels were used as a basis to establish soil remedial goals for the Mines site, taking into account the current and reasonably likely future land use, as presented in Section 6. These remedial goals are applicable to soil at the Mines site where COC concentrations in soil exceed the remedial goals and background and will be achieved through a combination of soil hot spot removal, consolidation and covering, and institutional controls.

OAR 340-122-085(7) requires that, for hot spots of contamination in media other than ground water or surface water, the feasibility of treatment be evaluated. This evaluation is discussed further in Section 11.

Further assessment of the White King pond will determine the effects of arsenic on aquatic invertebrates. Additional action, if determined to be necessary, to address unacceptable risk levels in the aquatic environment will be documented in an ESD or ROD amendment.

OAR Chapter 345, Division 92 (Standards for the Siting of Uranium Mills), Section 31(1) (Standards Relating to Public Health and Safety of Uranium Mill Operation, Decommissioning and Waste Disposal). This regulation establishes standards that applicants must meet to obtain a site certificate for uranium mills and related and supporting facilities, which includes any site for the permanent disposal of mine overburden. This regulation is not applicable to the remedial action because it applies to an application to prospectively construct and operate a uranium mill and supporting facilities. However, this regulation is relevant and appropriate because it establishes allowable radiation equivalent criteria for any member of the public, criteria for release of airborne effluents and protection criteria for population doses. The remedy will meet these requirements by covering the stockpiles and reducing radiation exposures to below the levels established under these requirements (25 millirems to whole body, 75 millirems to thyroid, etc).

OAR Chapter 345, Division 95 (Construction, Operation and Decommissioning Rules for Uranium Mills), Section 90 (Public Health Impacts). This regulation applies to uranium mills and related and supporting facilities operated pursuant to a site certificate agreement. It is relevant and appropriate because it establishes allowable radiation equivalent criteria for any member of the public, criteria for release of airborne effluents and protection criteria for population doses. The remedy will meet these requirements by covering the stockpiles and reducing overall radiation exposures.

36 CFR Part 228 (Minerals), Section 8. These regulations are intended to minimize adverse environmental impacts on National Forest Service System surface resources in connection with operations authorized by Federal mining. In addition to requiring compliance with applicable air quality, water quality, and solid waste standards, this section requires that operators, to the extent practicable, harmonize operations with scenic values through construction of structures which blend with the landscape, take all practicable measures to maintain and protect fisheries and wildlife habitat that may be affected by operations, construct and maintain all roads to assure adequate drainage and minimize damage to soil, water and other resource values, and reclaim the surface disturbed in operations by controlling erosion, landslides, and water runoff, isolating, removing or controlling toxic materials, reshaping and revegetation of disturbed areas where reasonably practicable, and rehabilitating fisheries and wildlife habitat. This section is relevant and appropriate to the remedial action at the Mines site. The selected remedy will meet these requirements by excavating and consolidating stockpiles to blend with the natural contours at the Mines site. Placement of a soil cover and establishment of vegetation on the stockpiles will also prevent erosion and reduce infiltration which will protect Augur Creek and its associated wetland habitat. Neutralization of the White King pond may allow the establishment of a diverse aquatic community which will enhance and protect this habitat.

Oregon Administrative Rules, Chapter 345, Division 95 (Oregon Construction, Operation and Decommissioning Rules for Uranium Mills) Section 118 (Mine Reclamation). Because this regulation applies to uranium mills and related and supporting facilities operated pursuant to a site certificate agreement, it is not applicable to the remedial action. However, it is relevant and appropriate because it requires that a mine site be reclaimed by modifying overburden and waste dump slopes to grades favorable to reclamation, implementing surface water management measures to prevent water collection or erosion in the area and to aid in revegetation of the site.

Oregon Administrative Rules, Chapter 632, Division 30 (Oregon Mined Land Reclamation Action) Section 27 (Minimum Standards for a Reclamation Plan). These rules prescribe procedures for obtaining an operating permit and complying with other requirements of the Oregon Mined Land Reclamation Act. Although a permit is not required at the Mines site pursuant to CERCLA 121(e)(1), portions of the substantive requirements are relevant and appropriate. A reclamation plan is not required to be submitted, although the remedial design will address certain minimum standards of a reclamation plan.

Migratory Bird Treaty Act (16 USC 703 et seq.). The Migratory Bird Treaty Act makes it unlawful to "hunt, take, capture, kill" or take various other actions adversely affecting a broad range of migratory birds, including mallards, ravens, juncos, nuthatchs, chickadees, and sandhill cranes (see 50 CFR 10.13) for a list of protected migratory birds) without prior approval by the Department of the Interior. This statute and implementing regulations are relevant and appropriate for protecting migratory bird species identified at the Mines site. The selected remedies will be carried out in a manner that avoids taking or killing of protected migratory bird species, including individual birds or their nests.

Other Criteria, Advisories, or Guidance To-Be-Considered (TBCs) for this remedial action

Additional policies, guidance, and other laws and regulations considered in the selection of the remedy, or which impact the remedy include the following:

Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, 40 C.F.R §192, Authority: Sec. 275 of the Atomic Energy Act of 1954, 42 U.S.C. §2022, as added by the Uranium Mill Tailings Radiation Control Act of 1978, Pub. L. 95-604, as amended.). This rule provides general design standards for cleanup and disposal of uranium tailings from inactive uranium processing sites as well as regulations to correct and prevent contamination of ground water from these sites. Because mine wastes are radiologically and geochemically similar to tailings, this standard is "to be considered" in design of the mine waste repository and soil cover.

International Atomic Energy Agency (IAEA) Guidelines (Technical Report Series No. 335). This document provides current practices used in design, siting, construction, and closeout of impoundment facilities for uranium mill tailings. Because the Mines site does not contain mill tailings, these guidelines are not directly applicable to the selected remedy. However, given the similarity between the wastes at the Mines site and those discussed in these guidelines and the similar goals they are "to be considered" in the design of the mine waste repository and soil cover.

The EPA action level of 4.0 pCi/l of indoor radon is commonly recognized by Federal (and ODEQ) agencies as an upper limit on radon exposure in the home. This is equivalent to 0.02 WL (Lung Cancer Risk from Indoor Exposures to Radon Daughters, Internal Commission on Radiological

Protection (ICRP) Publication 50, 1987, Pergamon Press, Oxford). The selected remedy will meet these levels by covering the stockpiles and preventing future residential use of the Mines site. Post construction monitoring of the mine waste repository will be conducted to confirm compliance with these levels.

U.S. Water Quality Criteria, 1986

The water quality criteria are standards for ambient surface water quality. These criteria present guidance on the environmental effects of pollutants that can be a useful reference in environmental monitoring. These criteria are "to be considered" in monitoring surface water at the Mines site and evaluating remediation levels.

13.3 COST-EFFECTIVENESS

The selected remedy is determined to be cost-effective. In making this determination, the following definition set forth in the NCP was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." (40 CFR §300.430(f)(1)(ii)(D)). This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (*i.e.*, were both protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its costs and hence this alternative represents a reasonable value for the money to be spent.

The estimated present worth cost of the selected remedy is as follows:

Alternative SP-3b (stockpiles): $6, 625,376
Alternative LL-3 (Lucky Lass): $535,000
Alternative WKPW-3 (White King Pond): $740,000

13.4 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES (OR RESOURCE RECOVERY TECHNOLOGIES) TO THE MAXIMUM EXTENT PRACTICABLE

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the Mines site. Of those alternatives that are protective of human health and the environment and comply with ARARs, the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against off-site treatment and disposal and considering State and community acceptance.

13.5 PREFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

The selected remedy utilizes alternative treatment (or resource recovery) technologies to the maximum extent practicable for this site. The remedy for the White King Pond, in-situ neutralization, satisfies the statutory preference for treatment as a principal element of the remedy.

Neutralization of the pond water increases the pH and reduces the concentration of COCs in the surface water. Treatment of the remaining threats, stockpile soils, was not found to be practicable due to the large volume.

13.6 FIVE-YEAR REVIEW REQUIREMENTS

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

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SECTION 14

DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan was released for public comment in October 1999. It identified Alternative SP-3b as the preferred alternative for the White King stockpiles which included recontouring of the protore stockpile, consolidation with the overburden stockpile, a 24-inch rock/soil cover, and a 20-foot setback from Augur Creek (excavation of 33,000 cubic yards). Comment was received from OOE indicating that Alternative SP-3b would not comply with State of Oregon requirements because the mine waste repository would still be within the Augur Creek floodplain.

In order to meet the State requirements Alternative SP-3b was modified as discussed in Section 9.3.1.3. This change requires movement of approximately 138,000 cubic yards of the protore stockpile from the Augur Creek floodplain. While this is a larger volume of material than was originally described in the FS for this alternative, this action serves the same purpose, to prevent erosion, and therefore could have been reasonably anticipated based on the information in the Proposed Plan.

The preferred alternative also identified a 12-inch rock bio-barrier covered by a 12-inch soil cover for the White King mine waste repository. After the public comment period, EPA sought additional input on the cover design from the U.S. Army Corps of Engineers (COE) and other technical experts within EPA. The COE and others commented that the 12-inch soil layer, underlain by a 6 or 12-inch bio-barrier (cobbles) may not perform as intended and may effectively prevent plant root penetration and the establishment of vegetation on the soil cover. The 12-inch rock layer would also cause the cover soil to dry out very quickly (from above and below) leaving inadequate moisture for good vegetation. A poor stand of vegetation could lead to a higher long-term erosion rates of the 12-inch soil cover. In addition it was felt that 12 inches of soil alone is too thin to provide protection against large rainfall events and that 24 inches of soil would provide additional protection from long-term erosion. Based upon this input, EPA changed the soil cover design from 24 inches of rock/soil to 24 inches of soil. While this design does not eliminate potential biointrusion of the burrowing animal species present at the Mines site (mice and shrews), it will allow for establishment of vegetation and protection from erosion. EPA felt that establishment of vegetation outweighed the potential impact from burrowing animals, which can be easily addressed through annual maintenance. In addition field observations of the piles indicate no presence of burrrowing animals and suggest the overburden material is not physically suited for constructing burrows. This change also could have been reasonably anticipated based on the information in the Proposed Plan.

Cost Calculations

The cost estimates presented in the FS and the Proposed Plan included a 25% allowance for contingencies. After the public comment period EPA re-evaluated the FS cost estimates. Typically the contingency percentage is included to cover costs for unforseen construction conditions as well as costs for incomplete designs during construction. While it is possible for total percentage contingencies to reach 35% on some projects, this usually happens at projects with complex treatment trains utilizing a number of treatment technologies. At the Mines site EPA believes that there are few unknowns that would complicate the implementation of the stockpile remedy. The material to be excavated is easily identified and the volumes are known. There are no complex treatment processes or specific difficulty in handling the material. Therefore, EPA believes that it is more appropriate to use a 10% figure for contingency to estimate the costs of the stockpile alternative SP-3b which is reflected in **Table 11-1.** While it was also felt that the construction management costs were higher than what is typically used, these values were not changed. There have been no changes made in the costs associated with the selected alternative for the White King pond or Lucky Lass stockpile.

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APPENDIX A

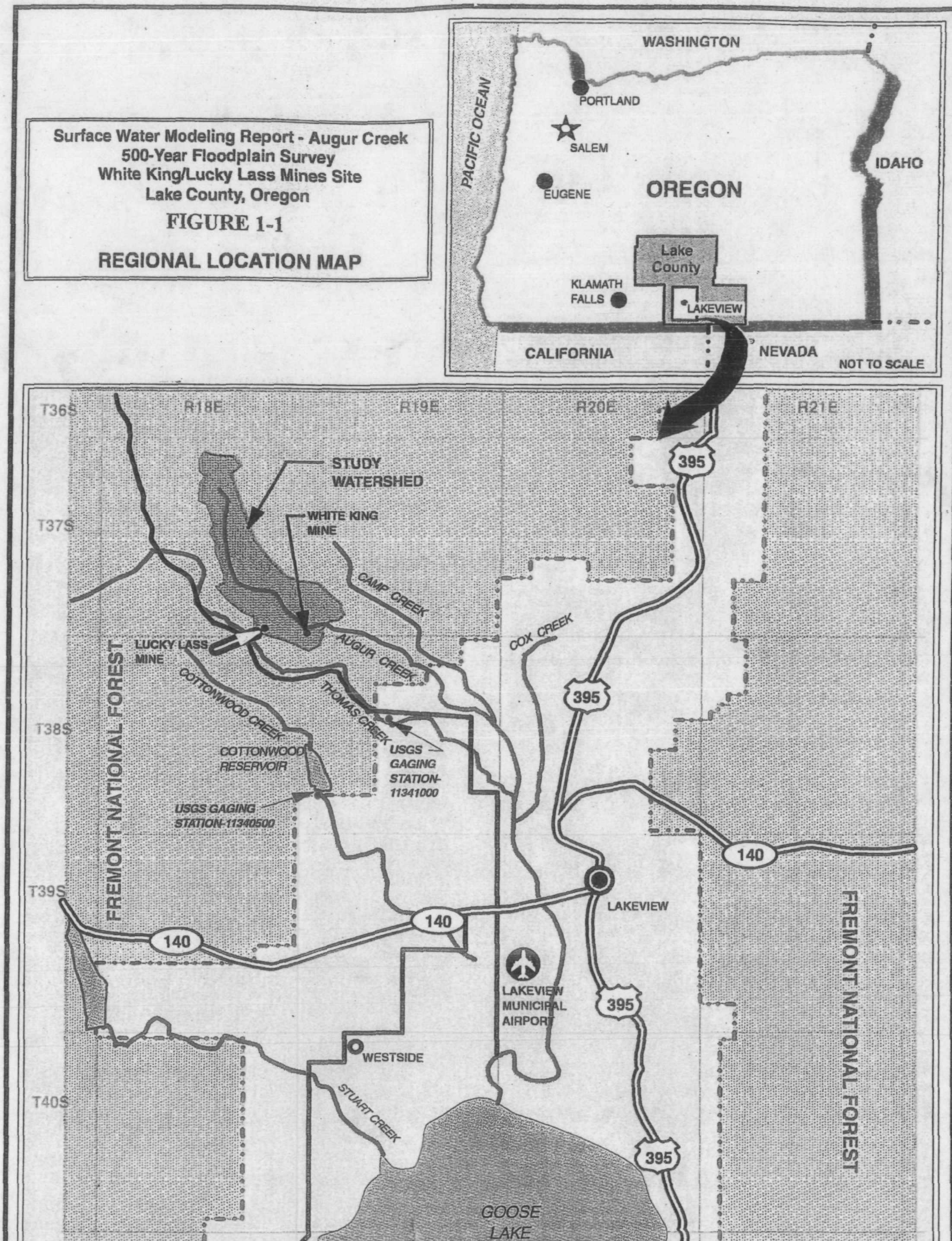
FIGURES FOR THE RECORD OF DECISION

WHITE KING/LUCKY LASS SITE

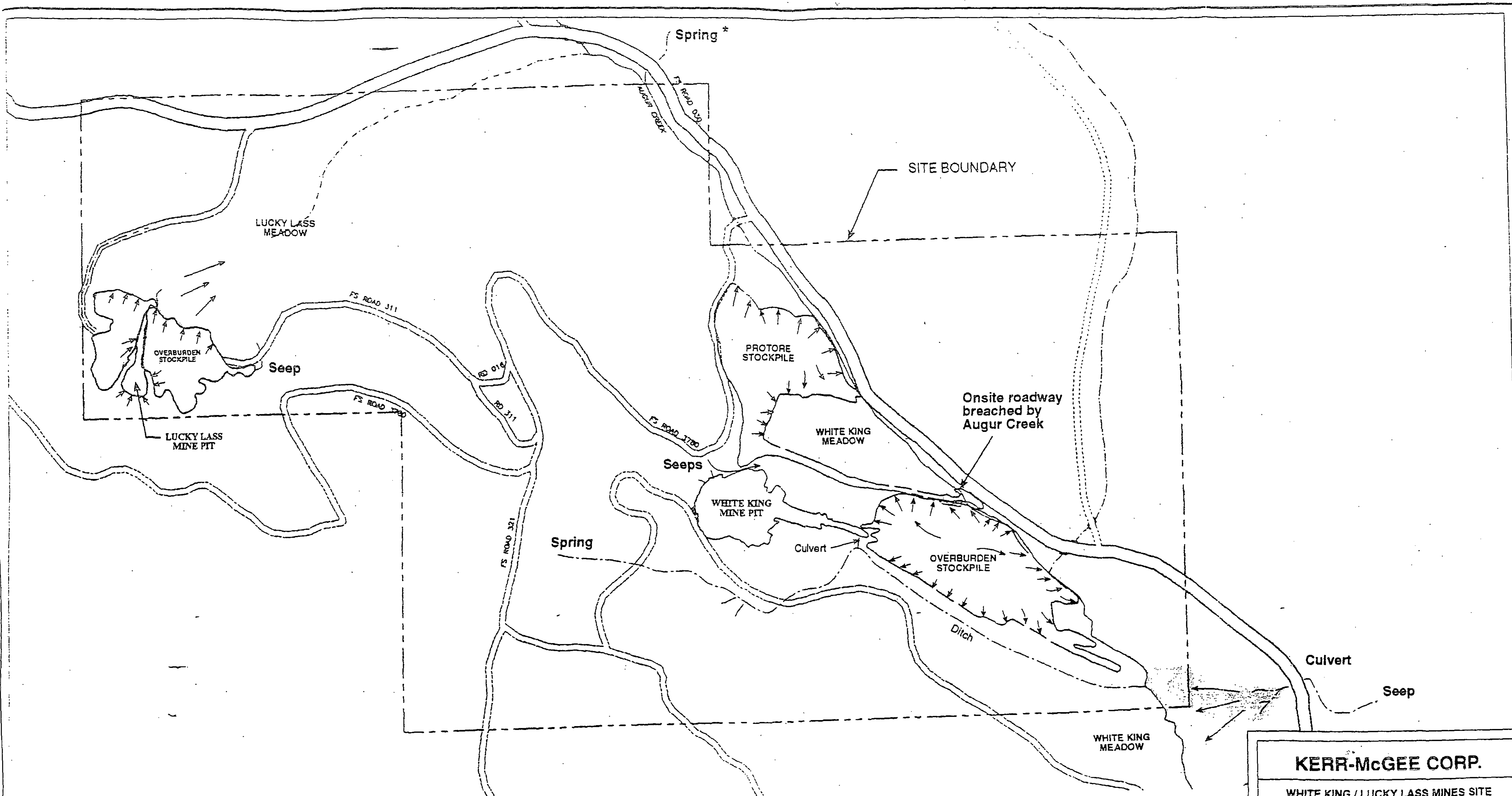
Surface Water Modeling Report - Augur Creek
500-Year Floodplain Survey
White King/Lucky Lass Mines Site
Lake County, Oregon

FIGURE 1-1

REGIONAL LOCATION MAP



KMCGOR13.PRE-10/95(REV11/95,1/96)C:\FLW\WORK



* Flowed continuously during all sampling events.

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97-297 Fig2-2SurfWat.fh7

N

0 400 800
Scale in Feet

EXPLANATION

Overland Flow
Ephemeral Flow
Ephemeral Sheet Flow

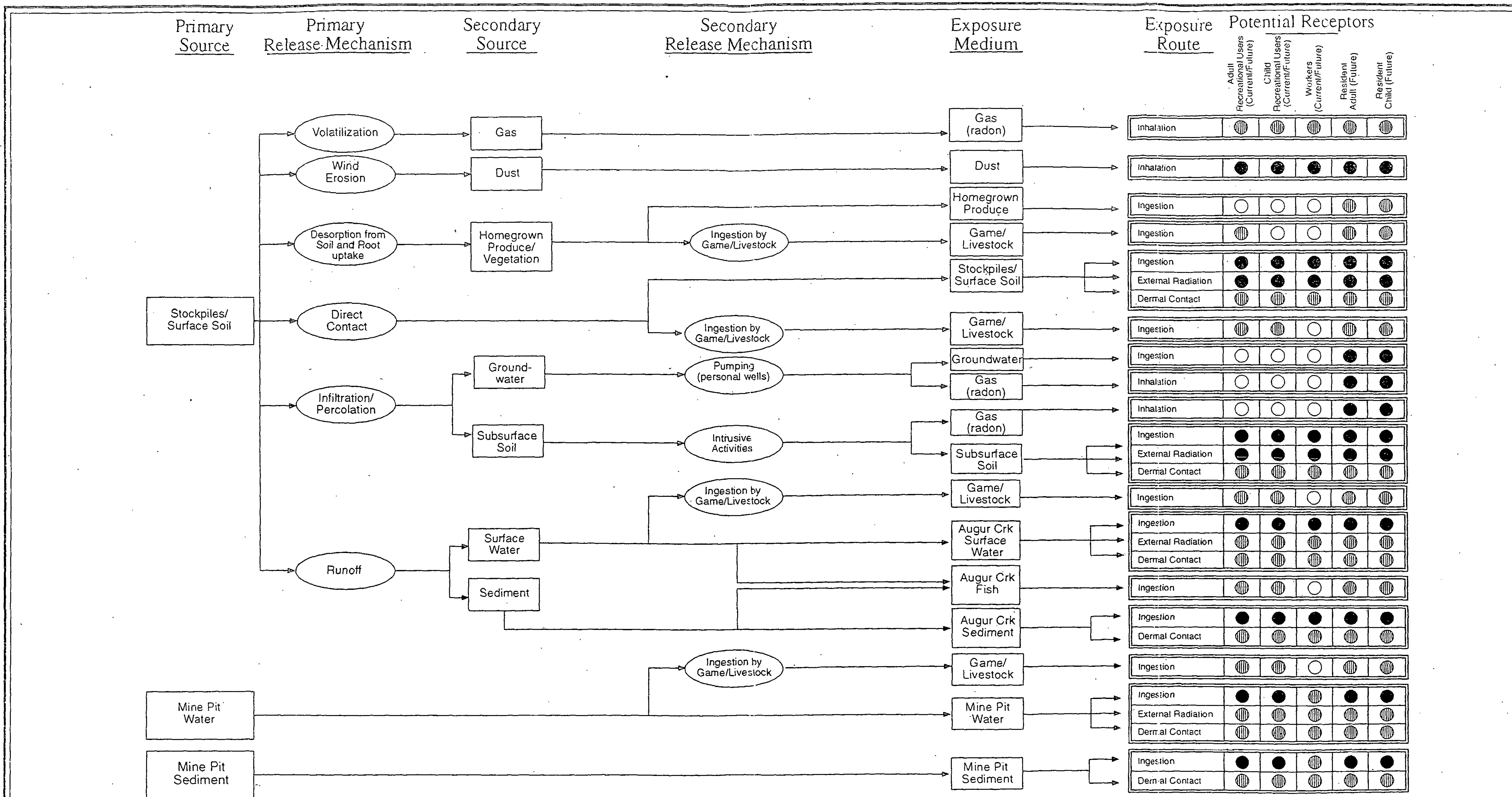
KERR-McGEE CORP.

WHITE KING / LUCKY LASS MINES SITE
LAKEVIEW, OREGON

Major Features

White King/LL Site

FIGURE 1-2



Explanation

- Exposure route will be included in quantitative analysis
- Exposure route eliminated from quantitative analysis based on qualitative and/or quantitative reasoning
- Not considered a potential exposure route for this receptor

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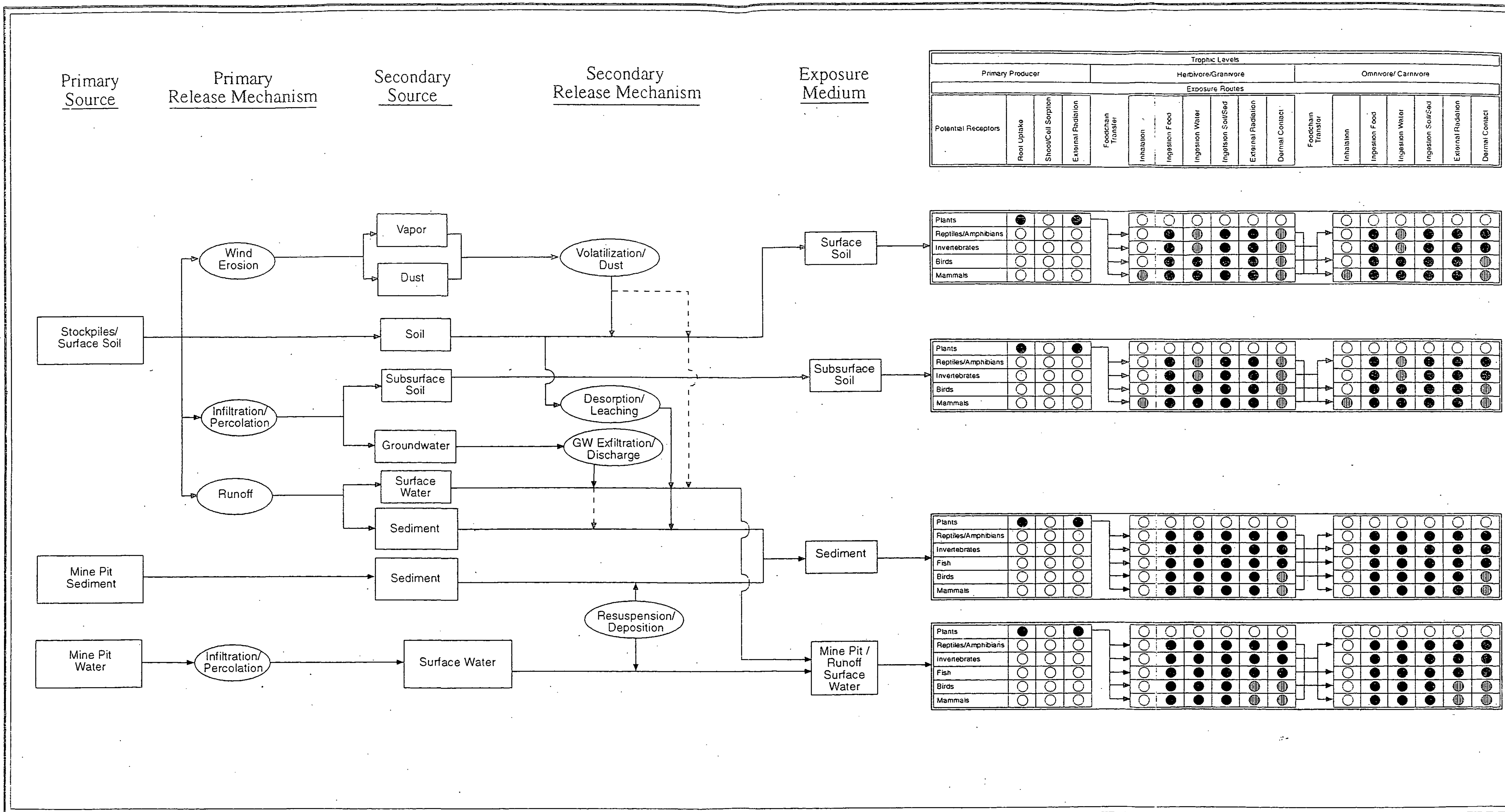
July 1996

WHITE KING / LUCKY LASS MINES SITE
LAKEVIEW, OREGON

Human Health Conceptual Site Model

FIGURE 5-1



Explanation	
● Primary exposure route	← Primary route of migration
◍ Potential exposure route	← - - Potential route of migration
○ No exposure expected	

Note:
Crossover lines indicate that release mechanisms contribute to the exposure medium and/or food chain transfer occurs between the receptors

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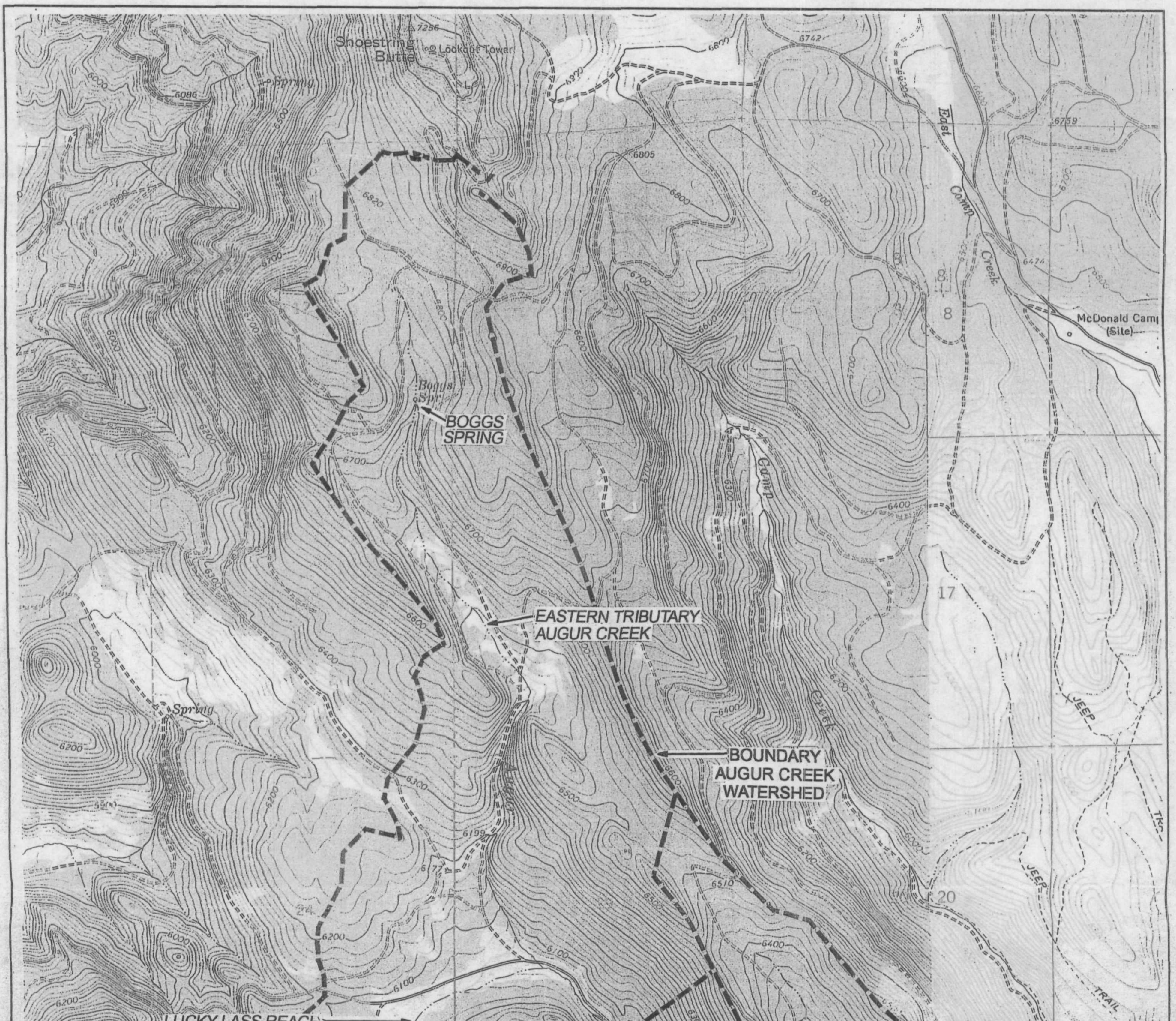
June 1996

WHITE KING / LUCKY LASS MINES SITE
LAKEVIEW, OREGON

Ecological Conceptual Site Model

FIGURE 5-2



LEGEND:

Approximate boundary of the upper watershed of Augur Creek at and above White King Mine

NORTH

0 1000 2000 4000
SCALE IN FEET

500 200 0 500
SCALE IN METERS

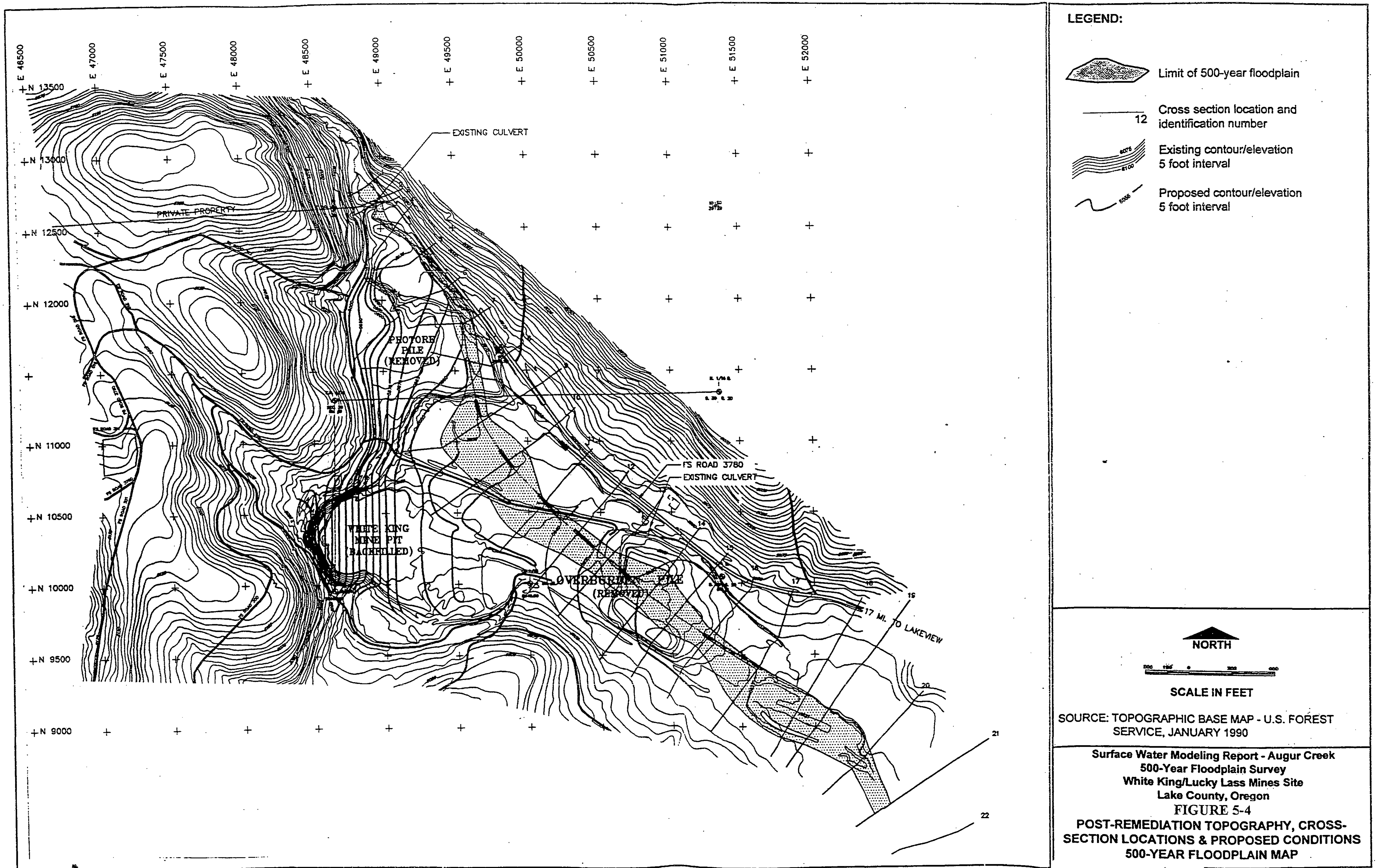
SOURCE:
Base map adapted from USGS 7.5 minute series quadrangles (1:24,000)Big Baldy, OR., Clover Flat, OR., Cox Flat, OR., and Shoestring Butte, OR., all dated 1964 and photorevised 1980

Surface Water Modeling Report - Augur Creek
500-Year Floodplain Survey
White King/Lucky Lass Mines Site
Lake County, Oregon

FIGURE 5-3

AUGUR CREEK WATERSHED MAP AT AND ABOVE WHITE KING MINE

KMCGOR14/1-11/95(REV1/96)C:\FLW\WORK

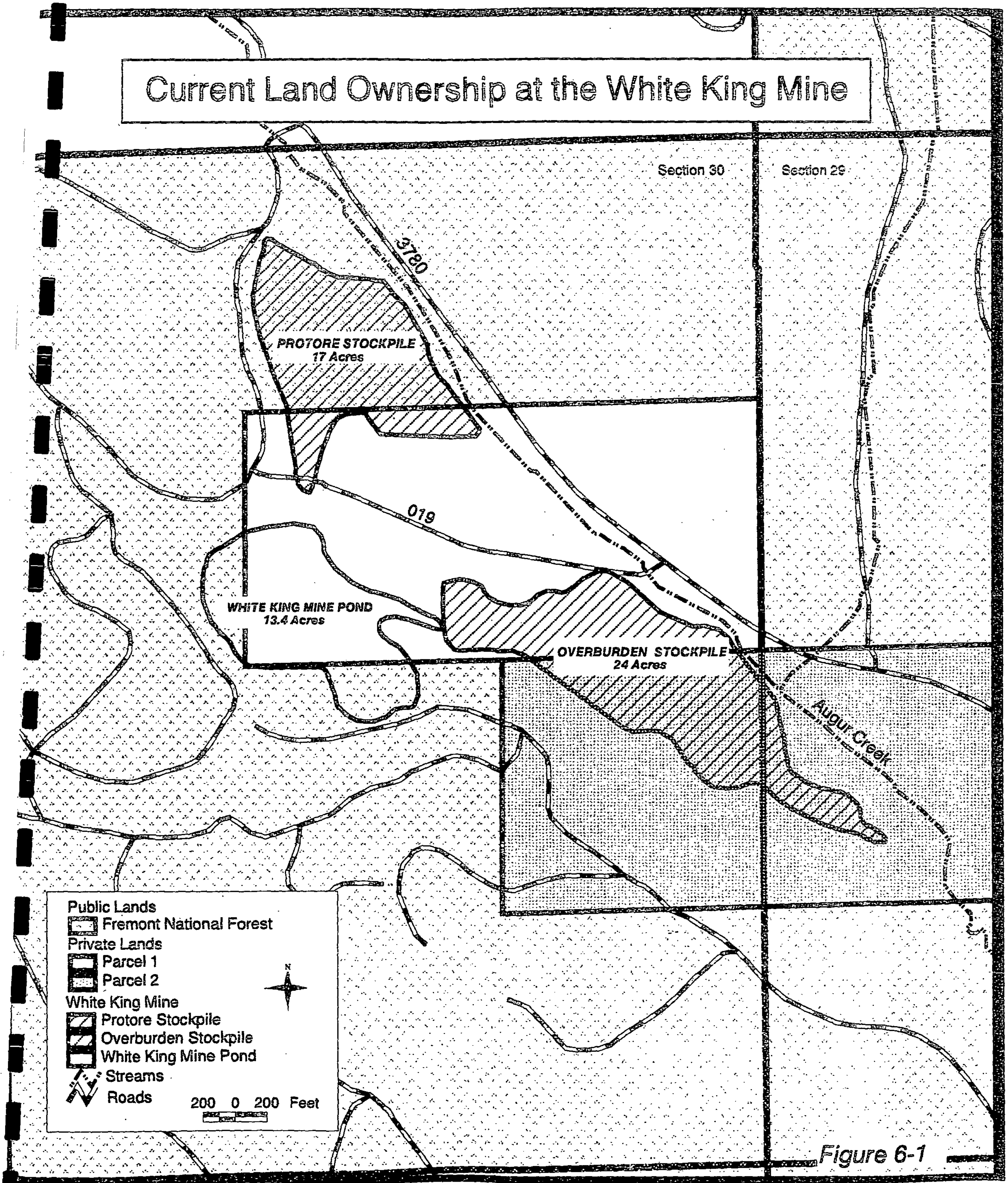


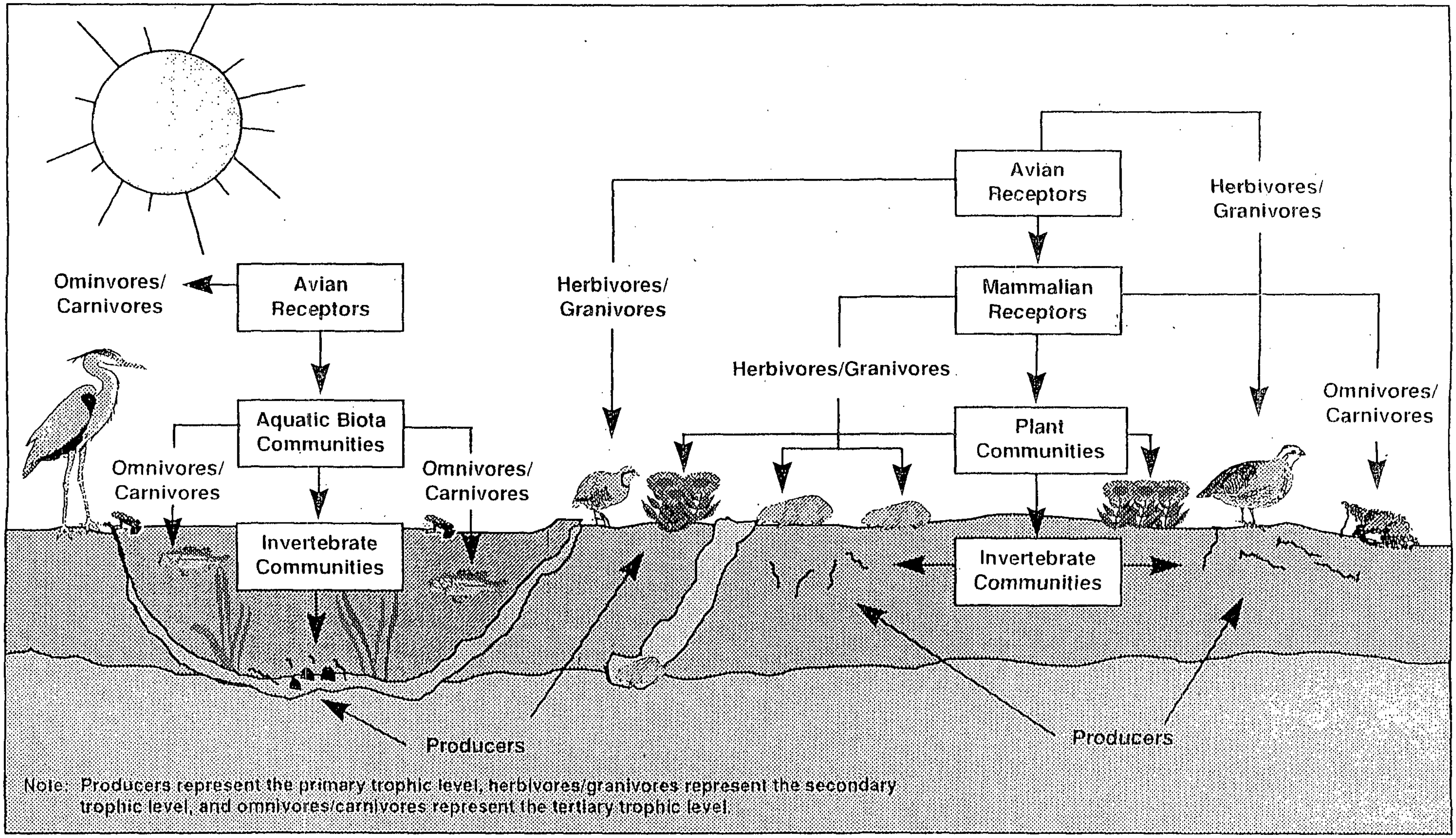
SOURCE: TOPOGRAPHIC BASE MAP - U.S. FOREST SERVICE, JANUARY 1990

Surface Water Modeling Report - Augur Creek
500-Year Floodplain Survey
White King/Lucky Lass Mines Site
Lake County, Oregon

FIGURE 5-4

POST-REMEDIATION TOPOGRAPHY, CROSS-SECTION LOCATIONS & PROPOSED CONDITIONS 500-YEAR FLOODPLAIN MAP


Current Land Ownership at the White King Mine
Section 30
Section 29
3780
PROTORE STOCKPILE
17 Acres
019
WHITE KING MINE POND
13.4 Acres
OVERBURDEN STOCKPILE
24 Acres
Augur Creek
Public Lands
Fremont National Forest
Private Lands
Parcel 1
Parcel 2
N
White King Mine
Protore Stockpile
Overburden Stockpile
White King Mine Pond
Streams
Roads
200 0 200 Feet
Figure 6-1



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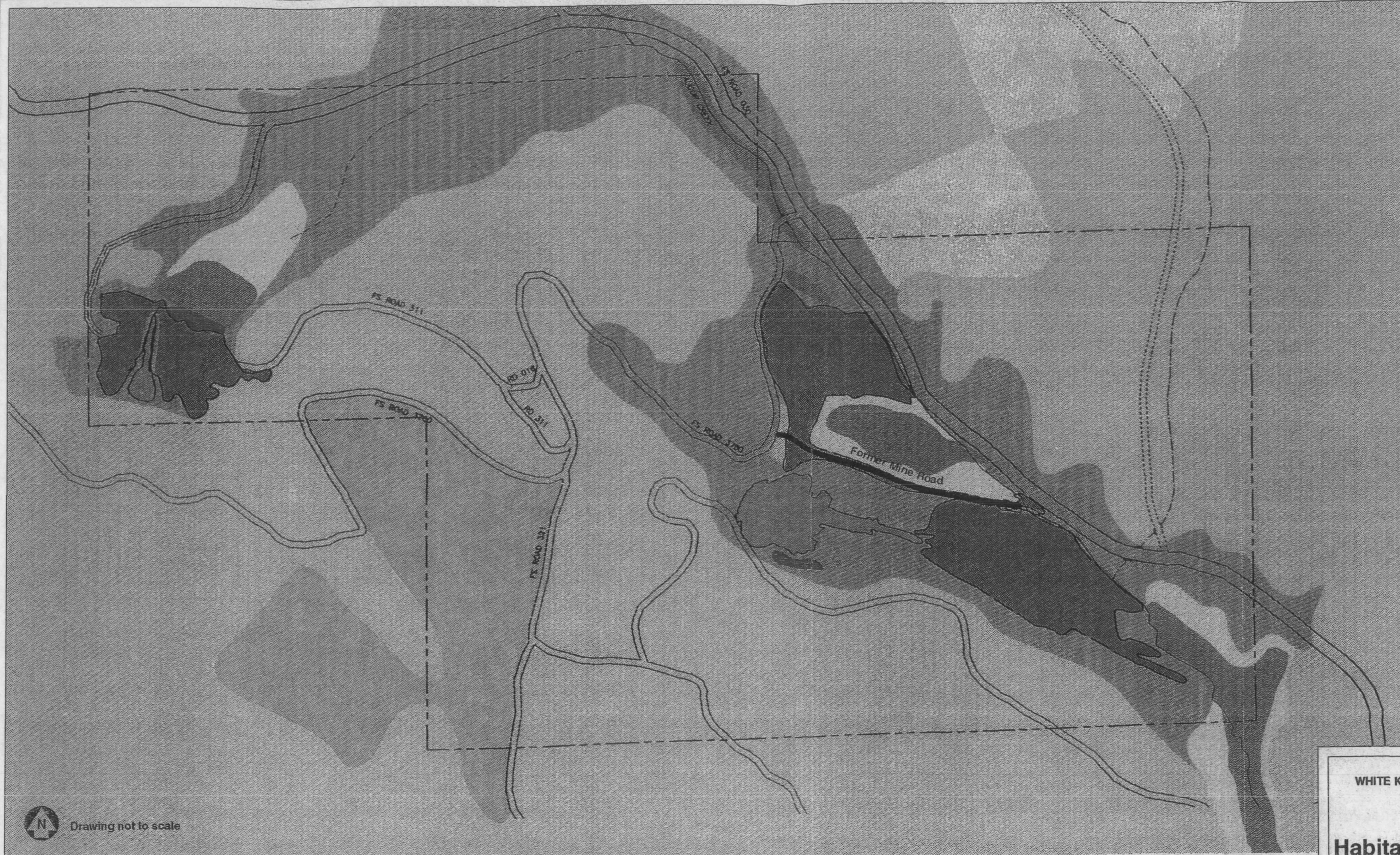
KERR-McGEE CORP.

WHITE KING / LUCKY LASS MINES SITE
LAKEVIEW, OREGON

Receptor and Community Feeding Relationships Model

FIGURE 7-1



NOTE: Boundaries are approximate, based on field surveys and aerial photographs.

EXPLANATION

Mixed Conifer Forest	Wet Meadow	Shrub - Steppe
Deciduous Forest	Relict Clear-cut	Stockpile
Dry Meadow	Recent Clear-cut	Water

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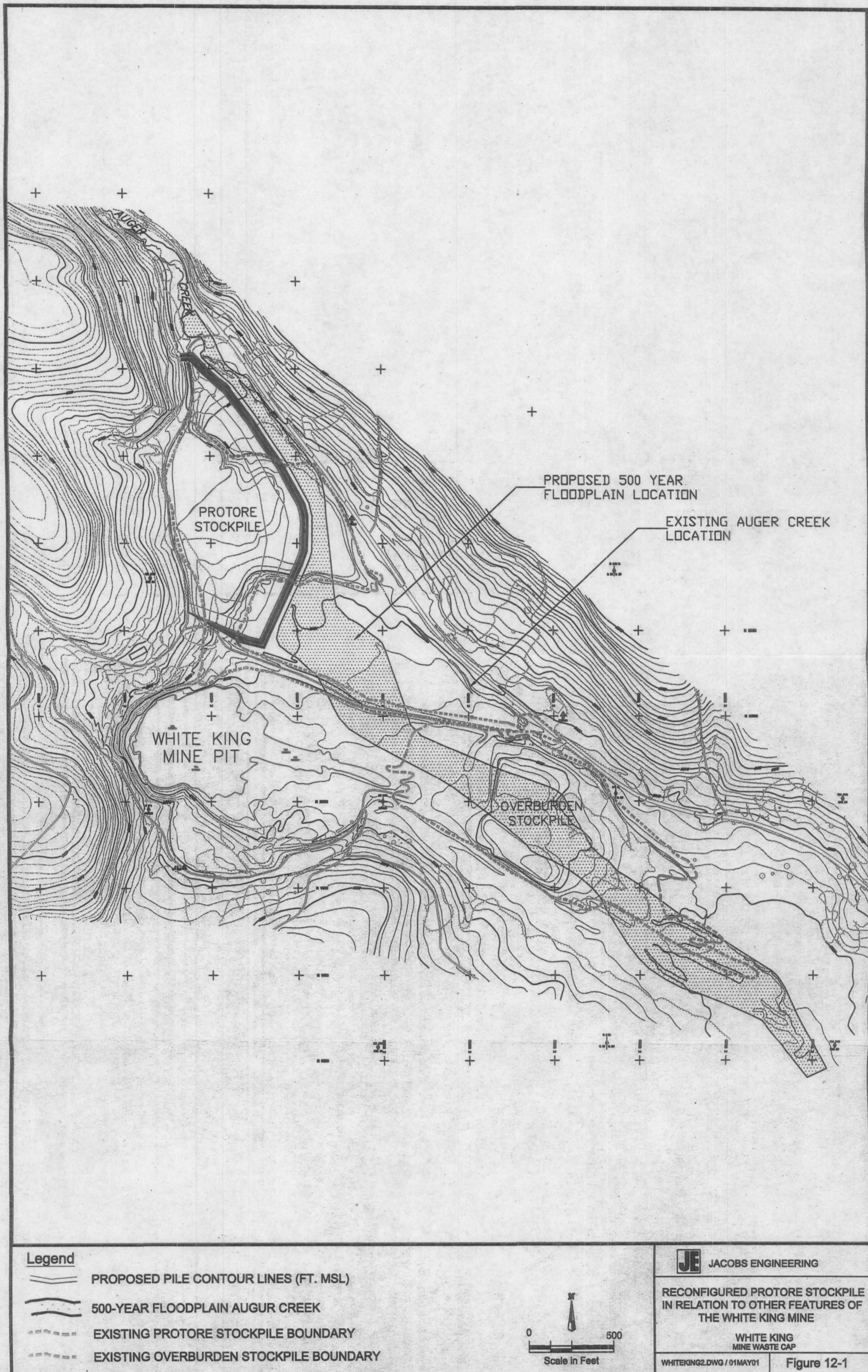
WHITE KING / LUCKY LASS MINES SITE
LAKEVIEW, OREGON

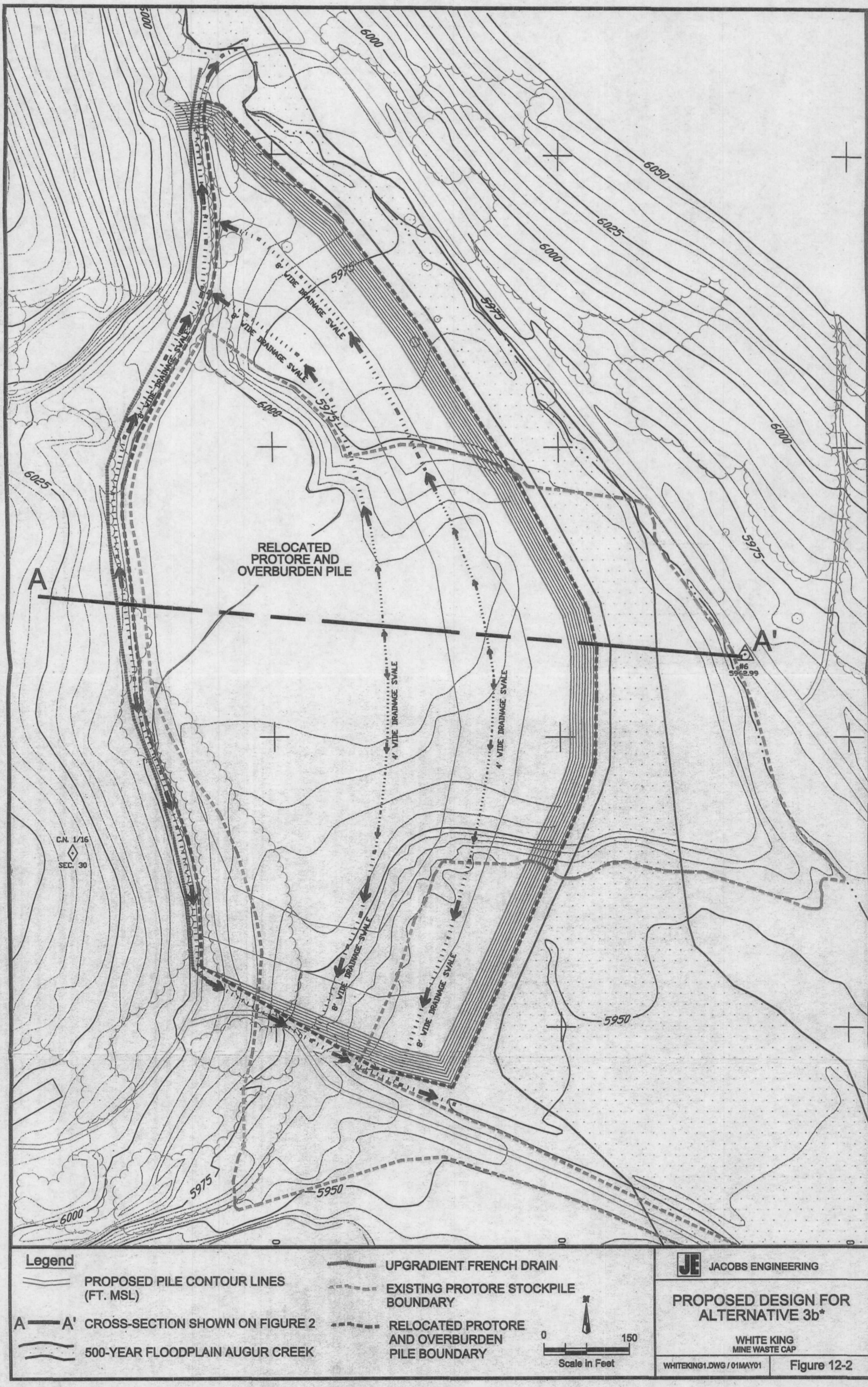
Habitat Characterization Map

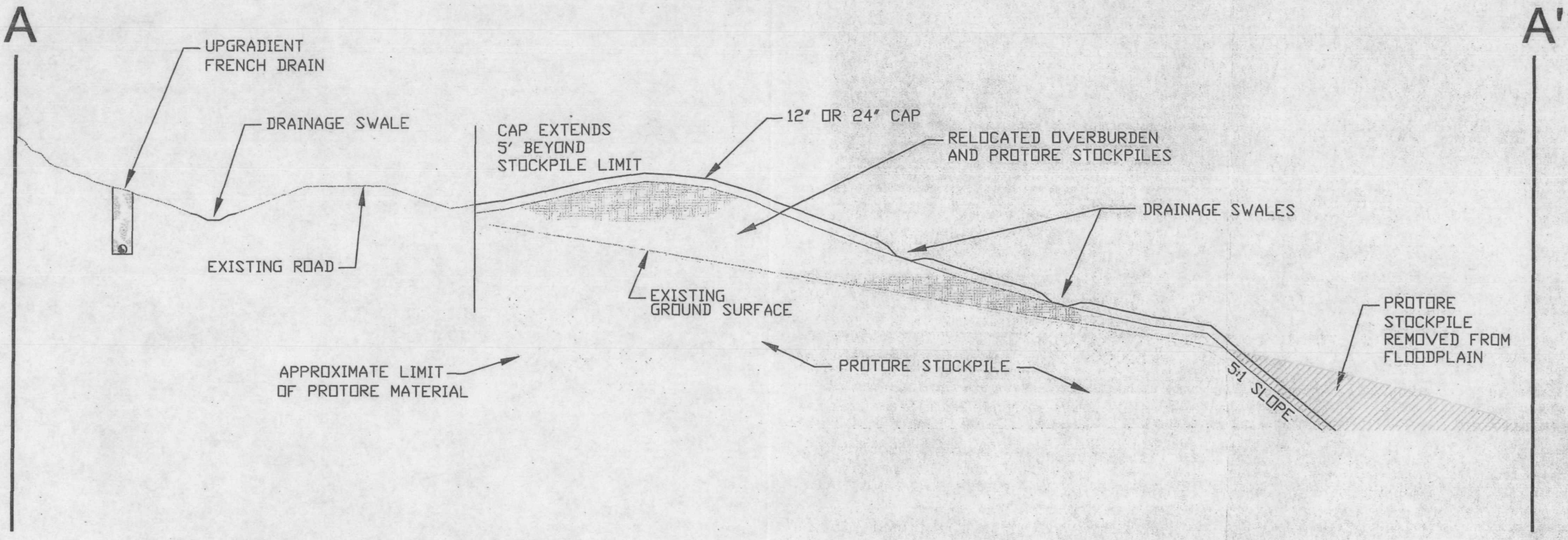
FIGURE 7-2



RECONFIGURED PROTORE STOCKPILE IN RELATION TO OTHER FEATURES OF THE WHITE KING MINE

Figure 12-1


RELOCATED
PROTORE AND
OVERBURDEN PILE
A
A'
8' WIDE DRAINAGE SWALE
4' WIDE DRAINAGE SWALE
6050
6025
6000
5975
5950
C.N. 1/16
SEC. 30
#6
5962.99
Legend
PROPOSED PILE CONTOUR LINES (FT. MSL)
A — A' CROSS-SECTION SHOWN ON FIGURE 2
500-YEAR FLOODPLAIN AUGUR CREEK
UPGRADIENT FRENCH DRAIN
EXISTING PROTORE STOCKPILE BOUNDARY
RELOCATED PROTORE AND OVERBURDEN PILE BOUNDARY
0
150
Scale in Feet
JACOBS ENGINEERING
PROPOSED DESIGN FOR ALTERNATIVE 3b*
WHITE KING
MINE WASTE CAP
WHITEKING1.DWG / 01MAY01
Figure 12-2



CONSTRUCTION DETAILS OF FRENCH DRAIN AND DRAINAGE SWALES ON FIGURE 3

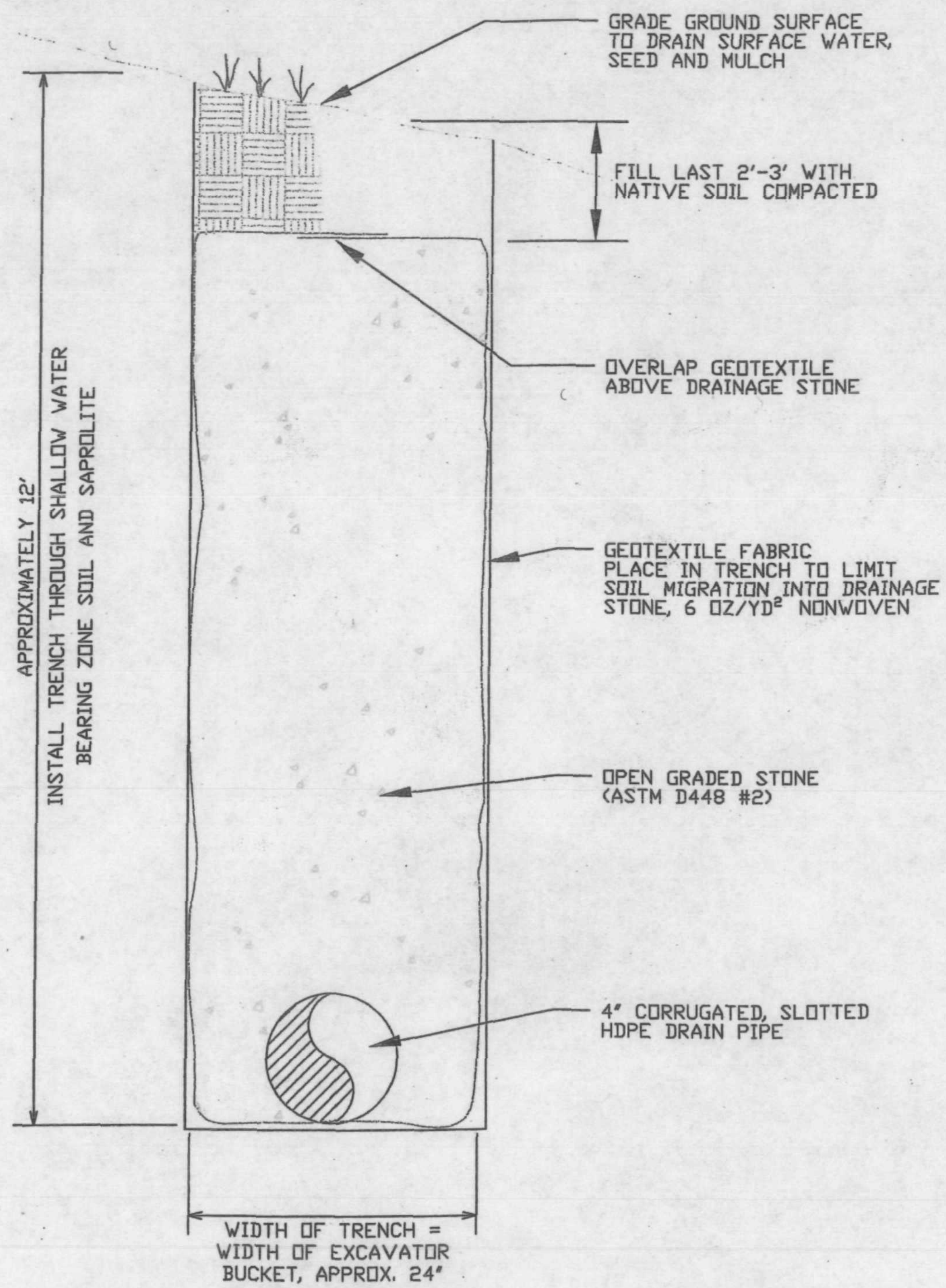
NOT TO SCALE

JE JACOBS ENGINEERING

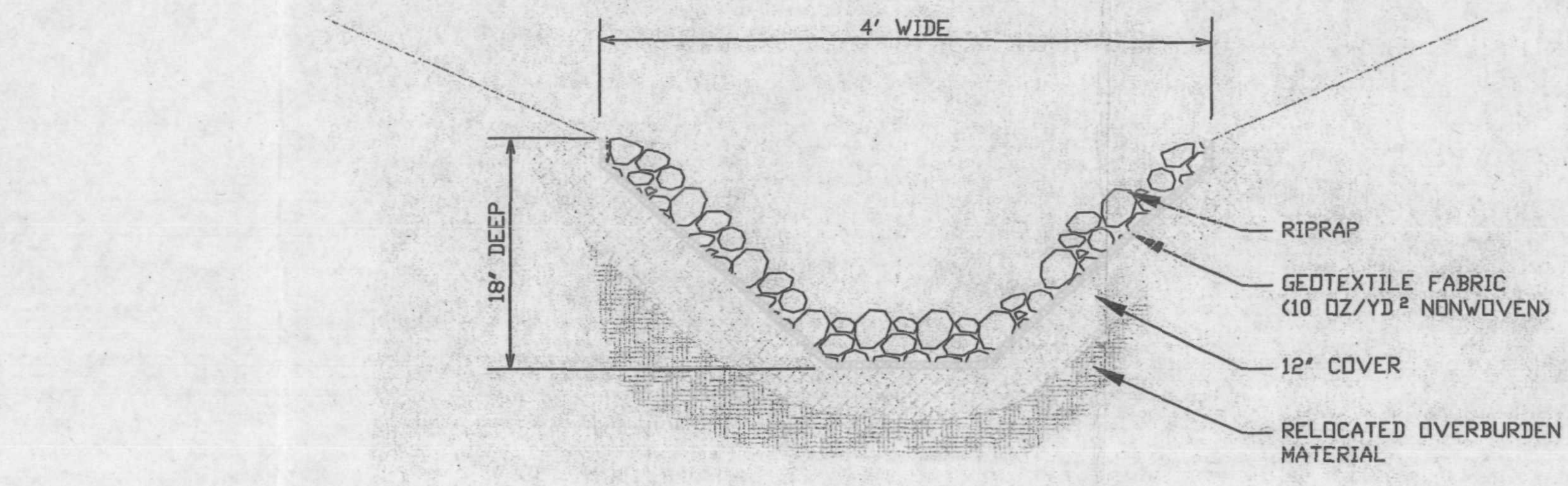
CROSS-SECTION A - A'
CAPPED CONSOLIDATED PROTORE AND OVERBURDEN STOCKPILE
ALTERNATIVE 3b*
WHITE WING
MINE WASTE CAP

CROSSECTION.DWG / 13AUG00 SB

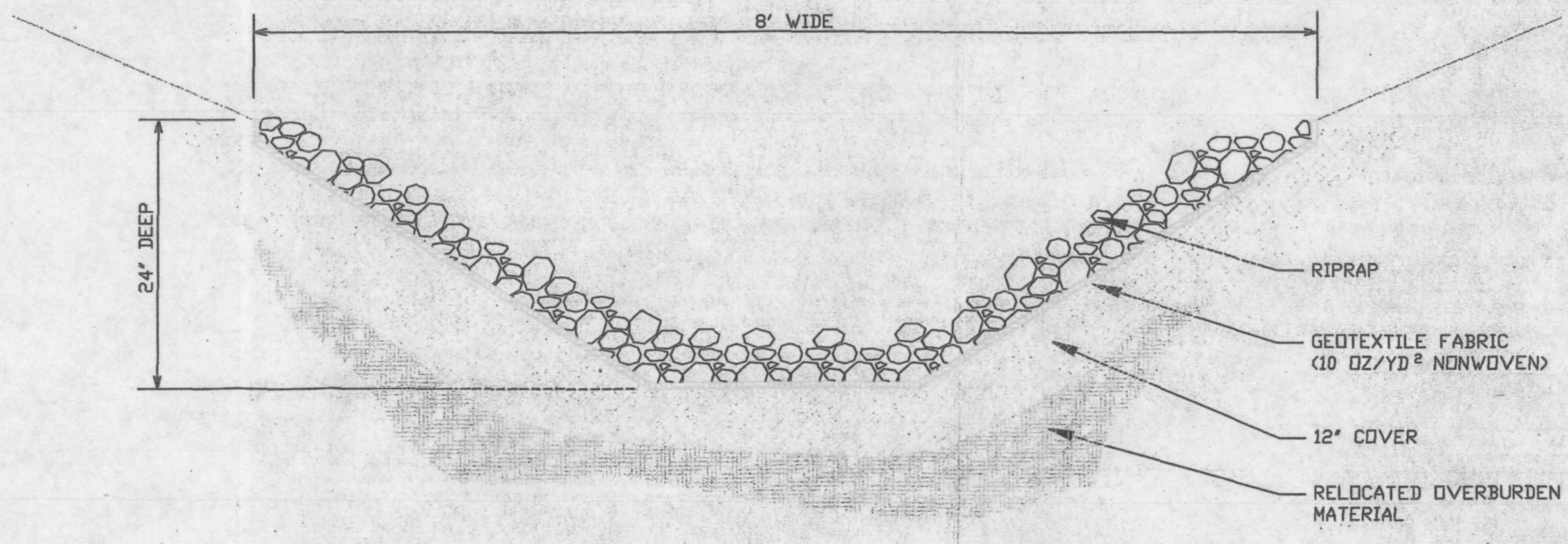
FIGURE 12-3



UPGRADIENT FRENCH DRAIN TO
INTERCEPT SHALLOW GROUNDWATER



4' WIDE DRAINAGE SWALE



8' WIDE DRAINAGE SWALE

JE JACOBS ENGINEERING

PROPOSED DESIGN FOR
ALTERNATIVE 3b*
DETAILS

WHITE WING
MINE WASTE CAP

SECTIONS.DWG / 13AUG00SB

FIGURE 12-4

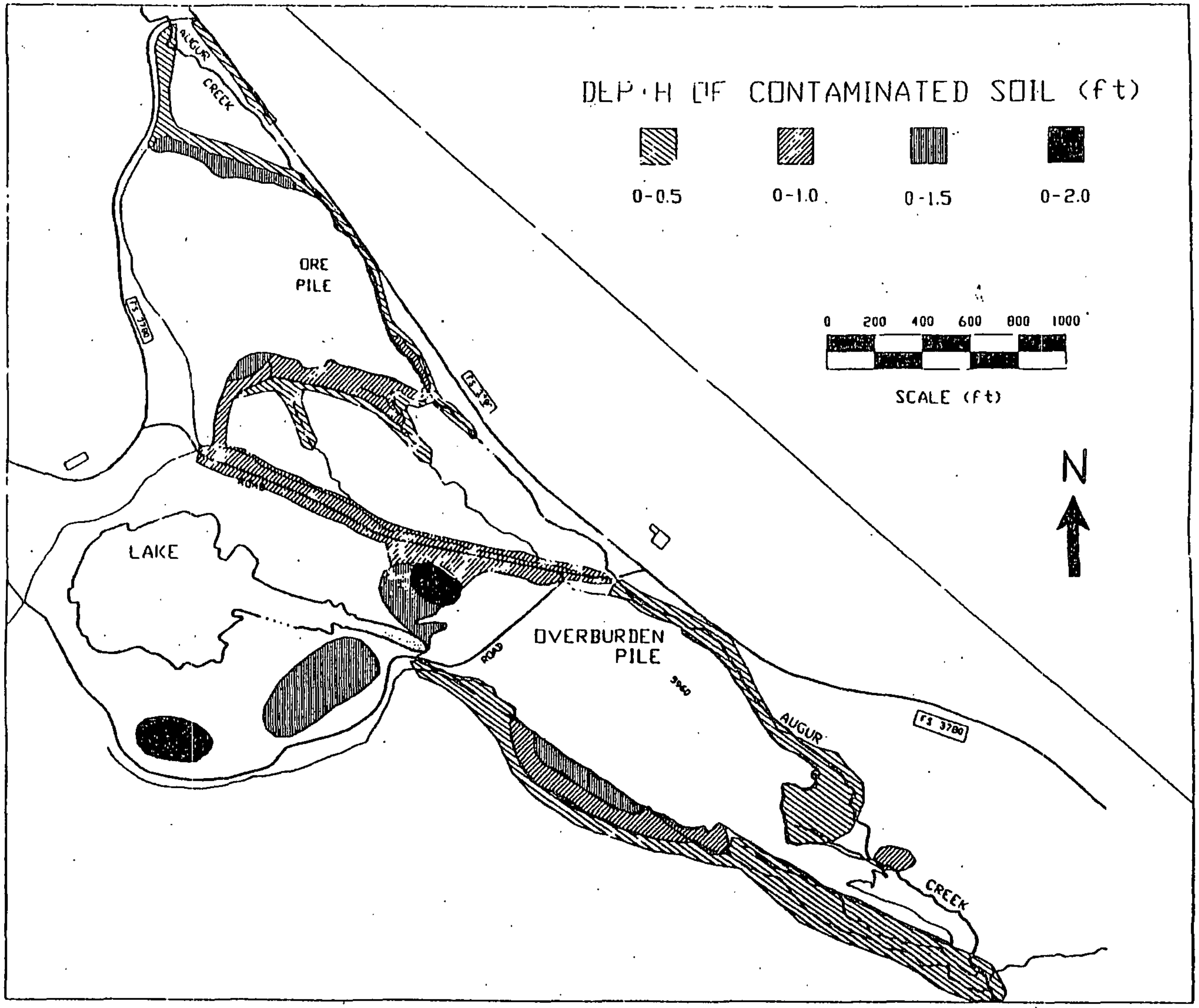


Figure C-5. Approximate Areas and Depths of Contaminated Soil at the White King Mine (from Robinet et al., 1990)

Figure 12–5

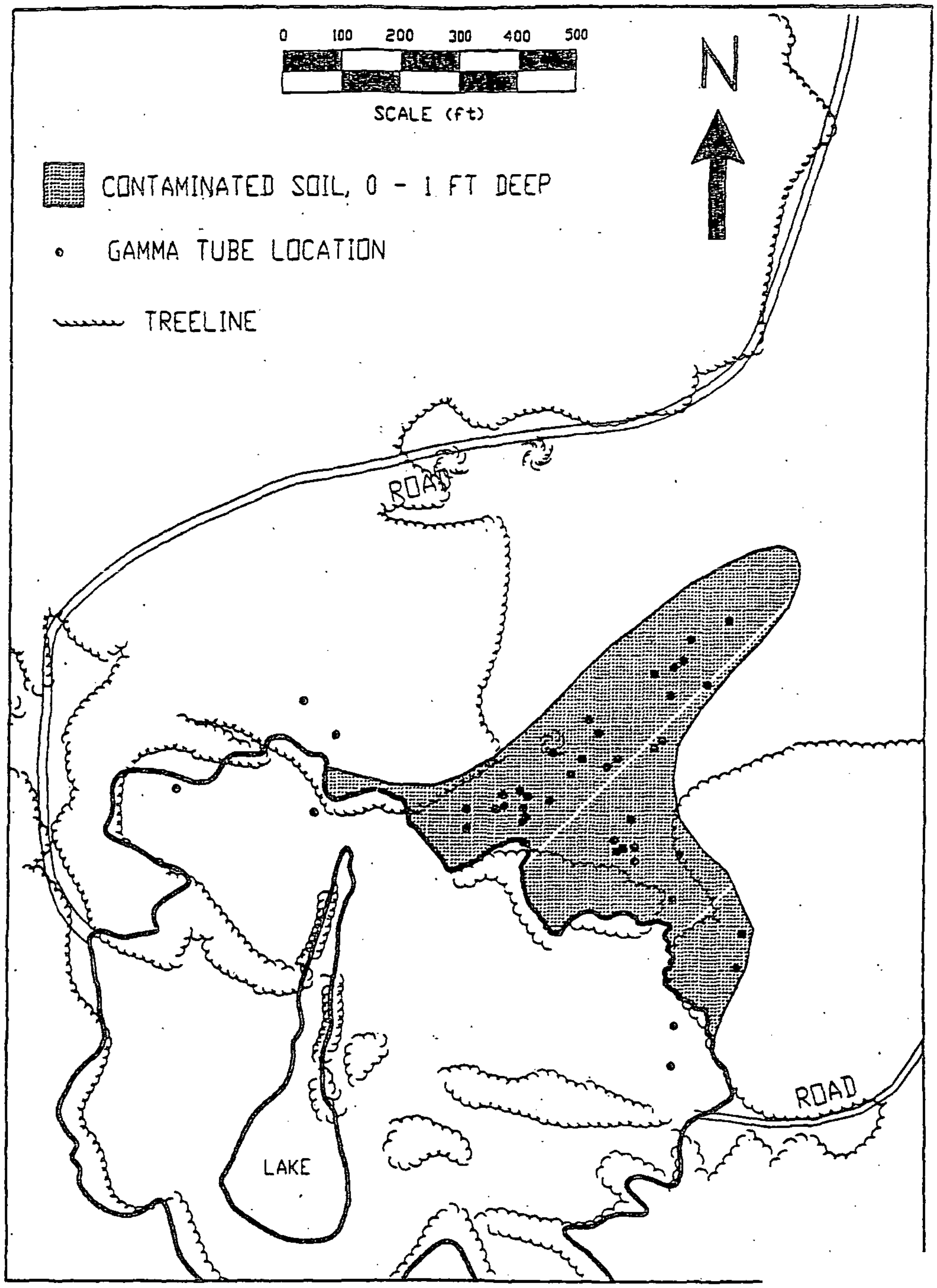


Figure 12–6 **Areas of Contaminated Soil at the Lucky Lass Mine (from Robinet et al., 1990)**

APPENDIX B

TABLES FOR THE RECORD OF DECISION

WHITE KING/LUCKY LASS SITE

TABLE 5-1 -White King Surface and Subsurface Soil—Comparisons to Standards

	Surface and Subsurface Soil			UMTRA	90% UCL		Selected for	90% UCL		Selected for
	Background		5Xs Background[a]	Soil Standards	Pile Concentration		Detailed Discussion[d]	Off-Pile Concentration		Detailed Discussion[d]
Inorganics (mg/kg)										
Aluminum	106000		530000	NV	23365		N	43783		N
Antimony	9.9	UJ	49.5	NV	76.4		Y	5.47		N
Arsenic	5.2		26	NV	2315		Y	111		Y
Barium	598		2990	NV	160		N	277		N
Beryllium	2		10	NV	4.27		N	2.49		N
Cadmium	0.67		3.35	NV	0.45		N	0.36		N
Chromium	57.2		286	NV	15.2		N	28.2		N
Cobalt	37.7		189	NV	9.27		N	17.45		N
Copper	61.2		306	NV	31		N	43.3		N
Iron	64800		324000	NV	17834		N	30348		N
Lead	13.6		68	NV	64.4		N	12.8		N
Manganese	1640		8200	NV	408		N	1478		N
Mercury	0.06	U	0.3	NV	11.3		Y	0.48		Y
Molybdenum*	NA		——	NV	535		N	8.07		N
Nickel	68.7		344	NV	16.6		N	31.3		N
Selenium	0.63	UJ	3.15	NV	2.04		N	3.6		N
Silver	0.95		4.75	NV	0.57		N	1.12		N
Strontium*	NA		——	NV	74.9		N	52.1		N
Thallium	0.47		2.35	NV	3.87		Y	1.26		N
Vanadium	159		795	NV	35.4		N	77.3		N
Zinc	88.8		444	NV	54.2		N	62		N
Radionuclides (pCi/g)										
Uranium 234	0.7		3.5	NV	24.3		Y	12.5		Y
Uranium 238	0.73		3.65	NV	23.2		Y	13.1		Y
Radium 226	0.31		1.55	5.36[b]/15.31[c]	35.8		Y	1.2		N
Radium 228	0.53		2.65	NV	0.92		N	0.54		N
Thorium 228*	NA		——	NV	——		N	——		N
Thorium 230	1.15		5.75	NV	37.4		Y	2.63		N
Thorium 232	0.75		3.75	NV	0.99		N	0.49		N

a - When the background concentration was undetected 5 times the detection limit was used

b - UMTRA surface soil standard is the background value plus 5 pCi/g

c - UMTRA subsurface soil standard is the background value plus 15 pCi/g

d - The compounds selected for detailed discussion had 90% UCL concentrations greater than the standard (or greater than 5 times background if no standard exists).

NA - Not analyzed

NV - No value

* Pre-RI data did not have background samples collected

U = Undetected

J = Estimated

TABLE 5-2 -Lucky Lass Surface and Subsurface Soil—Comparisons to Standards

	Surface and Subsurface Soil			UMTRA	90% UCL	Selected for	90% UCL	Selected for
	Background		5Xs above Background[a]	Soil Standards	Pile Concentration	Detailed Discussion	Off-Pile Concentration	Detailed Discussion
Inorganics (mg/kg)								
Aluminum	85185		425925	NV	26745	N	31122	N
Antimony	9.7		48.5	NV	4.83	N	3.96	N
Arsenic	3.9		19.5	NV	5.75	N	3.8	N[e]
Barium	663		3315	NV	452	N	288	N
Beryllium	2.4		12	NV	2.04	N	1.51	N
Cadmium	0.55		2.75	NV	0.39	N	0.28	N
Chromium	25		125	NV	11.8	N	17	N
Cobalt	28		140	NV	11.9	N	10.8	N
Copper	53		265	NV	24.5	N	27.1	N
Iron	47200		236000	NV	22765	N	24262	N
Lead	16.7		83.5	NV	12.5	N	13.4	N
Manganese	3020		15100	NV	1626	N	770	N
Mercury	0.06	U	0.3	NV	0.03	N	0.03	N
Molybdenum*	NA		------	NV	------	N	3.22	N
Nickel	36		180	NV	13.8	N	16.7	N
Selenium	1		5	NV	1.28	N	1.45	N
Silver	0.72		3.6	NV	1.01	N	1.58	N
Strontium*	NA		------	NV	------	N	119	N
Thallium	0.36		1.8	NV	0.38	N	0.35	N
Vanadium	128		640	NV	49.9	N	54.5	N
Zinc	107		535	NV	49.7	N	51	N
Radionuclides (pCi/g)								
Uranium 234	1.35		6.75	NV	3.67	N	2.11	N
Uranium 238	1.19		5.95	NV	3.69	N	2.19	N
Radium 226	0.72		3.6	5.36[b]/15.31[c]	2.49	N	1.47	e
Radium 228	0.79		3.95	NV	1.08	N	0.77	N
Thorium 228*	NA		------	NV	------	N	------	N
Thorium 230	1.14		5.7	NV	3.68	N	2.05	N
Thorium 232	1.08		5.4	NV	1.08	N	0.74	N

a - When the background concentration was undetected, 5 times the detection limit was used.

b - UMTRA surface soil standard is the background value plus 5 pCi/g.

c - UMTRA subsurface soil standard is the background value plus 15 pCi/g.

d - The compounds selected for detailed discussion had 90% UCL concentrations greater than the standard (or greater than 5 times background if no standard exists).

e - Arsenic and Radium-226 were selected for detailed discussion even though they do not meet the criteria for selection. Their selection at Lucky Lass was based only on their significance at White King

NA - Not analyzed.

NV - No value.

* Pre-RI data did not have background samples collected.

U = Undetected

Table 5-3 Stockpile Soil Comparisons

	White King Protore Pile				White King Overburden Pile				Lucky Lass Overburden Pile			
	Ave Conc. Surface Soil	Ave. Conc. 2.5-10ft	Ave. Conc 10ft-Nat	Ave. Conc. Native-10ft.	Ave Conc. Surface Soil	Ave. Conc. 2.5-10ft	Ave. Conc 10ft-Nat	Ave. Conc. Native-10ft	Ave Conc. Surface Soil	Ave. Conc. 2.5-10ft	Ave. Conc 10ft-Nat	Ave. Conc. Native-10ft
Antimony	32.9	39.61	103.38	12.5	ND	89.3	7.65	ND	ND	ND	ND	4.53
Arsenic	3945.25	2797.5	776.43	1086	769	3677.6	756.45	59.53	11.9	3.68	2.28	6.42
Mercury	NR	10.51	3.87	13.1	NR	20.77	2.34	0.98	ND	ND	ND	ND
U -234	NR	54.77	12.09	9.32	NR	22.88	12.22	2.98	NR	1.87	1.76	4.46
U-238	NR	54.08	12.25	8.11	NR	20.2	11.09	2.8	NR	2.02	1.81	4.18
Ra-226	NR	36.88	11.66	6.58	NR	53.14	28.37	1.64	NR	1.99	1.43	2.33
Ra-228	NR	0.89	0.87	0.52	NR	1.11	0.87	0.48	NR	1.11	1.07	0.84.
Th-230	NR	61.77	10.28	6028	NR	51.85	22.06	2.74	NR	1.71	1.48	4.6
Th-232	NR	1.07	0.88	0.89	NR	1.27	0.8	0.4	NR	1.01	1.23	0.86

Inorganics - mg/kg
Radionuclides - pCi/g
ND- Non-detected
NR- No result

TABLE 5-4 –Augur Creek, Seep, and Drainage Channel Surface Water Comparison to Standards

Analytes	Background		5X Background[a]	AWQC[b] Freshwater Chronic	Oregon Standard	90% UCL		Selected for Detailed Discussion[c]
Total Inorganics (µg/L)								
Aluminum	1600		8000	N/A	-	654		N
Antimony	50	U	250	1600	1600	25.0	U	N
Arsenic	10.5		52.5	190[d]	190[d]	11.1		N
Barium	44.4		222	N/A	-	28.0		N
Beryllium	1	U	5	5.3[e]	5.3	0.5	U	N
Cadmium	2	U	10	1.1[f]	1.1	1.0	U	N
Chromium	5	U	25	11	11	2.5		N
Cobalt	3	U	15	N/A	-	1.5		N
Copper	7.6		38	12[f]	12	1.7		N
Iron	917		4585	1000	1000	626		N
Lead	2.1		10.5	3.2[f]	3.2	3.3		Y
Manganese	46.3		231.5	N/A		95		N
Mercury	0.1	U	0.5	0.012	0.012	0.06		Y
Nickel	11.7		58.5	160[f]	160	5.7		N
Selenium	1.8		9	35	35	1.0		N
Silver	3	U	15	0.12	0.12	1.5	U	N
Thallium	1	U	5	40[f]	40	0.55		N
Vanadium	4.7		23.5	N/A	-	2.6		N
Zinc	10		50	110[f]	110	6.7		N
Radionuclides (pCi/L)								
Uranium 234	0.5	U	2.5	N/A	-	2.67		Y
Uranium 238	0.5	U	2.5	N/A	-	2.82		Y
Radium 226	0.5	U	2.5	N/A	-	0.28		N
Radium 228	1	U	5	N/A	-	0.5	U	N
Thorium 230	0.98		4.9	N/A	-	0.36		N
Thorium 232	0.5	U	2.5	N/A	-	0.2	U	N

a - If background concentrations were undetected, 5x the detection limit was used.

b - EPA, 1986, Oregon Regulation 340.41; Ambient Water Quality Criteria.

c - Analyte was selected for detailed discussion if the 90% UCL concentration was > the standard or > 5x background if no standard exists.

d - Trivalent arsenic standard is used in lieu of total arsenic standard.

e - Insufficient data to develop criteria; value presented is the Lowest Observed Effects Level.

f - Hardness dependent criteria (100 mg/L used).

N/A: Not available.

U = Undetected

TABLE 5-5 -White King and Lucky Lass Ponds Surface Water—Comparison to Standards

Analytes	AWQC[*] Freshwater Chronic	White King Pond 90% UCL		Selected for Detailed Discussion[d]	Lucky Lass Pond 90% UCL		Selected for Detailed Discussion[d]
Total Inorganics (µg/L)							
Aluminum	N/A	4130		N	4379		N
Antimony	1600	25.0	U	N	25	U	N
Arsenic	190[a]	99.4		N	17.4		N
Barium	N/A	33.7		N	27.8		N
Beryllium	5.3[b]	5.2		N	1.0	U	N
Cadmium	1.1[c]	2.0	U	N	2.0	U	N
Chromium	11	4.9	U	N	4.9	U	N
Cobalt	N/A	44.9		N	2.9	U	N
Copper	12[c]	12.2		Y	4.0		N
Iron	1000	1677		Y	2911		Y
Lead	3.2[c]	0.9		N	1.8		N
Manganese	N/A	1170		N	111		N
Mercury	0.012	0.1		Y	0.1	U	N
Nickel	160[c]	101		N	9.8	U	N
Selenium	35	6.0		N	2.5		N
Silver	0.12	2.9	U	N	2.9	U	N
Thallium	40[c]	1.9		N	1.0	U	N
Vanadium	N/A	2.0	U	N	7.4		N
Zinc	110[c]	159		Y	8.1		N
Radionuclides (pCi/L)							
Uranium 234	N/A	8.35		N	0.43		N
Uranium 238	N/A	8.17		N	0.79		N
Radium 226	N/A	0.81		N	0.62		N
Radium 228	N/A	0.98	U	N	0.98	U	N
Thorium 230	N/A	0.26		N	0.39		N
Thorium 232	N/A	0.19	U	N	0.3	U	N

* EPA, 1986, Oregon Regulation 340.41; Ambient Water Quality Criteria

N/A: Not available.

a: Trivalent arsenic standard is used in lieu of total arsenic standard.

b: Insufficient data to develop criteria; value presented is the Lowest Observed Effects Level.

c: Hardness dependent criteria (100 mg/l used).

d: Analyte was selected for detailed discussion if the 90% UCL concentration was greater than the standard. No background concentrations exist for pond surface water.

Note: For analytes that were all undetected, the "90% UCL" is the 90% UCL of the reported detection limits.

U = Undetected

TABLE 5-6 -Augur Creek and Drainage Channel Sediment—Comparison to Standards

Analytes	Background		5X Background[a]	Ontario Sediment Quality Standards Lowest Effect Level	90% UCL		Selected for Detailed Discussion[b]
Inorganics (mg/kg)							
Aluminum	51100		255500	NV	38826.3		N
Antimony	7.5		37.5	NV	7.7		N
Arsenic	4.2		21	6	65.2		Y
Barium	316		1580	NV	275.7		N
Beryllium	1.7		8.5	NV	2.4		N
Cadmium	0.5		2.7	0.6	0.7		Y
Chromium	35.8		179	26	33.0		Y
Cobalt	25.9		129.5	NV	29.5		N
Copper	48.9		244.5	16	39.5		Y
Iron	50500		252500	20000	41343.8		Y
Lead	11.2		56	31	9.4		N
Manganese	1610		8050	460	2461.7		Y
Mercury	0.09	U	0.45	0.2	0.1		N
Nickel	44.8		224	16	39.9		Y
Selenium	1.3		6.5	NV	0.5		N
Silver	0.9		4.6	NV	0.7		N
Thallium	0.33	U	1.65	NV	0.5		N
Vanadium	139		695	NV	112.3		N
Zinc	83.1		415.5	120	111.9		N
Radionuclides (pCi/g)							
Uranium 234	0.94		4.7	NV	10.8		Y
Uranium 238	0.53		2.7	NV	11.6		Y
Radium 226	0.44		2.2	NV	0.8		N
Radium 228	0.42		2.1	NV	0.4		N
Thorium 230	0.58		2.9	NV	1.8		N
Thorium 232	0.5	U	2.5	NV	0.3		N

Background concentrations determined from samples collected upgradient from the Mines site in Augur Creek.

a - If background concentrations were undetected, 5x the detection limit was used.

b - Analyte was selected for detailed discussion if the 90% UCL concentration was > the lowest effect level standard or > 5x background if no lowest effect level standard exists.

NV - No value.

U = Undetected

TABLE 5-7 White King and Lucky Lass Ponds Sediment - Comparison to Standards

Analytes	Ontario Sediment Quality Standards Lowest Effect Level	White King Pond 90% UCL		Selected for Detailed Discussion[a]	Lucky Lass Pond 90% UCL		Selected for Detailed Discussion[a]
Inorganics (mg/kg)							
Aluminum	NV	36408		N	44883		N
Antimony	NV	219		N	N/A		N
Arsenic	6	24582		Y	6.5		Y
Barium	NV	149		N	240		N
Beryllium	NV	6.8		N	1.5		N
Cadmium	0.6	0.3	U	N	0.3	U	N
Chromium	26	15.8		N	14.9		N
Cobalt	NV	12.4		N	12.3		N
Copper	16	31.8		Y	31.6		Y
Iron	20000	58956		Y	32289		Y
Lead	31	43.5		Y	9.5		N
Manganese	460	304		N	739		Y
Mercury	0.2	9.6		Y	0.1	U	N
Nickel	16	19.1		Y	17.9		Y
Selenium	NV	0.5		N	0.7	U	N
Silver	NV	0.8		N	0.7		N
Thallium	NV	6.0		N	0.9		N
Vanadium	NV	60.0		N	67.5		N
Zinc	120	82		N	77.6		N
Radionuclides (pCi/g)							
Uranium 234	NV	53.8		N	20.42		N
Uranium 238	NV	53.3		N	18.92		N
Radium 226	NV	53.3		Y[b]	17.78		Y[b]
Radium 228	NV	1.04		N	1.04		N
Thorium 230	NV	21.8		N	16.79		N
Thorium 232	NV	1.19		N	1.51		N

a - There are no background values for pond sediment. Analyte was selected for detailed discussion if the 90% UCL concentration was greater than the lowest effect standard.

b - Ra226 was selected for detailed discussion because it exceeds the UMTRA soil standards of 5.36 and 15.31 pCi/g for surface and subsurface soil, respectively.

NV - No value.

N/A - All Lucky Lass pond antimony values were rejected during data validation.

Note: For analytes that were all undetected, the "90% UCL Detection" is the 90% UCL of the reported detection limits.

U = Undetected

TABLE 5-8 –Stockpile and Off-Pile Groundwater—Comparison to Standards

All Analytes	Background		5X Background[a]	Groundwater MCL	90% UCL Stockpile Concentration (µg/L)[b]		Selected for Detailed Discussion[c]	90% UCL Off-Pile Concentration (µg/L)		Selected for Detailed Discussion[c]
Total Inorganics (ug/L)										
Aluminum	3,280		16400	None	47,681		Y	28,173		Y
Antimony	50	U	250	6	68	U	N	31		Y
Arsenic	3.2		16	50	11,817		Y	22		N
Barium	39.8		199	1000	201		N	226		N
Beryllium	1	U	5	4	150		Y	4		N
Cadmium	2	U	10	10	13.8		Y	1.6		N
Chromium	5	U	25	50	26		N	25		N
Cobalt	3	U	15	None	222		Y	30		Y
Copper	2		10	1300	46		N	31		N
Iron	1,100		5500	None	41,350		Y	31,336		Y
Lead	3.6		18	50	10		N	6		N
Manganese	77.6		388	None	36,993		Y	1,022		Y
Mercury	0.1	U	0.5	2	1.0		N	1.5		N
Nickel	10	U	50	100	247		Y	110		Y
Selenium	5	U	25	10	4		N	3		N
Silver	3	U	15	50	14		N	2		N
Thallium	1	U	5	2	3.8		Y	1.7		N
Vanadium	4.6		23	None	25		Y	63		Y
Zinc	6		30	None	1,609		Y	145		Y
Sulfate (mg/L)	NA		NA	500[d]	1,757		Y	55		N
Radionuclides (pCi/L)										
Uranium 234	0.5	U	2.5	30[e]	5,110		Y	1		N
Uranium 238	0.5	U	2.5	30[e]	5,514		Y	1		N
Radium 226	0.5	U	2.5	5[e]	1.14		N	0.74		N
Radium 228	1	U	5	5[e]	0.87		N	1.26		N
Thorium 230	0.5	U	2.5	None	35		N[f]	0.42		N
Thorium 232	0.5	U	2.5	None	0.69		N	0.39		N
Radon	550		2750	300[d]	8,355		Y	508		N

[a] - When the background concentration was undetected, 5 times the detection limit was used.

[b] - Stockpile wells include: RFW-WK-MW-07-As/Ad - 10-As/Ad

[c] - The analytes selected for detailed discussion had 90% UCL concentrations greater than the standard (or greater than 5 times background if no standard exists).

[d] - Proposed MCL

[e] - 30 pCi/L is combined U 234 and U 238 UMTRA standard. 5 pCi/L is combined Ra 226 and Ra 228 UMTRA standard.

[f] - Thorium-230 will not be discussed in detail because there is no UMTRA groundwater protection standard for thorium-230 and thorium's solubility is greater than radium but less than uranium. Therefore, the uranium and radium discussions address thorium also.

U = Undetected

TABLE 5-8 –Stockpile and Off-Pile Groundwater—Comparison to Standards

All Analytes	Background		5X Background[a]	Groundwater MCL	90% UCL Stockpile Concentration (µg/L)[b]		Selected for Detailed Discussion[c]	90% UCL Off-Pile Concentration (µg/L)		Selected for Detailed Discussion[c]
Total Inorganics (ug/L)										
Aluminum	3,280		16400	None	47,681		Y	28,173		Y
Antimony	50	U	250	6	68	U	N	31		Y
Arsenic	3.2		16	50	11,817		Y	22		N
Barium	39.8		199	1000	201		N	226		N
Beryllium	1	U	5	4	150		Y	4		N
Cadmium	2	U	10	10	13.8		Y	1.6		N
Chromium	5	U	25	50	26		N	25		N
Cobalt	3	U	15	None	222		Y	30		Y
Copper	2		10	1300	46		N	31		N
Iron	1,100		5500	None	41,350		Y	31,336		Y
Lead	3.6		18	50	10		N	6		N
Manganese	77.6		388	None	36,993		Y	1,022		Y
Mercury	0.1	U	0.5	2	1.0		N	1.5		N
Nickel	10	U	50	100	247		Y	110		Y
Selenium	5	U	25	10	4		N	3		N
Silver	3	U	15	50	14		N	2		N
Thallium	1	U	5	2	3.8		Y	1.7		N
Vanadium	4.6		23	None	25		Y	63		Y
Zinc	6		30	None	1,609		Y	145		Y
Sulfate (mg/L)	NA		NA	500[d]	1,757		Y	55		N
Radionuclides (pCi/L)										
Uranium 234	0.5	U	2.5	30[e]	5,110		Y	1		N
Uranium 238	0.5	U	2.5	30[e]	5,514		Y	1		N
Radium 226	0.5	U	2.5	5[e]	1.14		N	0.74		N
Radium 228	1	U	5	5[e]	0.87		N	1.26		N
Thorium 230	0.5	U	2.5	None	35		N[f]	0.42		N
Thorium 232	0.5	U	2.5	None	0.69		N	0.39		N
Radon	550		2750	300[d]	8,355		Y	508		N

[a] - When the background concentration was undetected, 5 times the detection limit was used.

[b] - Stockpile wells include: RFW-WK-MW-07-As/Ad - 10-As/Ad

[c] - The analytes selected for detailed discussion had 90% UCL concentrations greater than the standard (or greater than 5 times background if no standard exists).

[d] - Proposed MCL

[e] - 30 pCi/L is combined U 234 and U 238 UMTRA standard. 5 pCi/L is combined Ra 226 and Ra 228 UMTRA standard.

[f] - Thorium-230 will not be discussed in detail because there is no UMTRA groundwater protection standard for thorium-230 and thorium's solubility is greater than radium but less than uranium. Therefore, the uranium and radium discussions address thorium also.

U = Undetected

R-8

Table 7-1

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current Worker
Medium: Surface soil
Exposure Medium: Surface soil

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point[1] Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
White King Mine Soil	Arsenic	2.7	4,140	ppm	25/25	2637	ppm	95% UCL
	Radium-226	0.24	291	pCi/g	31/31	75.6	pCi/g	95% UCL

Key

ppm: Parts per million
pCi/g: Picocurie per gram
95% UCL: 95% Upper Confidence Limit
[1] Exposure point concentrations calculated using surface soil data, except for radionuclides, where a combination of surface and subsurface data were used.

Table 7-2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future Worker
Medium: Surface soil
Exposure Medium: Surface soil

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration[1]	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
White King Mine Soil	Arsenic	2.7	13,794	ppm	58/58	5,010	ppm	95% UCL
	Radium-226	.2	291	pCi/g	49/49	15.4	pCi/g	95% UCL

Key

ppm: Parts per million
pCi/g: Picocurie per gram
95% UCL: 95% Upper Confidence Limit

[1] Exposure point concentrations were calculated incorporating both surface soil and subsurface soil up to depth of 6 feet.

Table 7-17

Risk Characterization Summary - Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Soil	White King Overburden Soil	Surface Soil	Arsenic	1.00E-2	6.36E-6	N/A	N/A	1E-2
		Surface Soil	Radium-226	1.92E-5	6.76E-9	N/A	1.12E-2	1.12E-2
							Soil Risk Total=	**2.12E-2**
Groundwater	White King Shallow Groundwater	Tap Water	Arsenic	1.65E-1	N/A	N/A	N/A	1.65E-1
			Radon	N/A	3.4E-3	N/A	N/A	3.4E-3
							Groundwater Risk Total=	**1.68E-1**
Surface Water	White King Pond	Surface Water	Arsenic	7.21E-6	N/A	N/A	N/A	7.21E-6
			Radium-226	4.32E-09	N/A	N/A	N/A	4.32E-9
							Surface Water Risk Total=	**7.21E-6**
Sediment	White King Pond	Sediment	Arsenic	2.21E-5	N/A	N/A	N/A	2.21E-5
			Radium-226	1.21E-08	N/A	N/A	N/A	1.21E-8
							Sediment risk total=	**2.21E-5**
							Total Risk =	**1.89E-1**

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-3

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future Recreational User
Medium: Surface/subsurface soil
Exposure Medium: Surface/subsurface soil

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration[1]	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
White King Mine Soil	Arsenic	2.7	13,794	ppm	58/58	5010	ppm	95% UCL
	Radium-226	0.20	291	pCi/g	49/49	15.4	pCi/g	95% UCL

Key

pCi/g: Picocurie per gram
ppm: Parts per million
95% UCL: 95% Upper Confidence Limit

[1] Exposure point concentrations were calculated incorporating both surface soil and subsurface soil up to depth of 6 feet.

Table 7-4

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current Recreational User
Medium: Surface/subsurface soil
Exposure Medium: Surface/subsurface soil

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration[1]	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
White King Mine Soil	Arsenic	425	4,140	ppm	36/38	915.2	ppm	Log 95% UCL
	Radium-226	3.3	291	pCi/g	46/46	18.9	pCi/g	Log 95% UCL

Key

pCi/g: Picocurie per gram
ppm: Parts per million
95% UCL: 95% Upper Confidence Limit

[1] Exposure point concentrations calculated using surface soil data, except for radionuclides, where a combination of surface and subsurface data were used.

Table 7-5

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future Resident
Medium: Surface/subsurface soil
Exposure Medium: Surface/subsurface soil

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration[1]	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
WhiteKing Overburden Mine Soil	Arsenic	425	11,700	ppm	9/9	11,700	ppm	95% UCL
	Radium-226	3.3	291	pCi/g	7/7	291	pCi/g	95% UCL
Lucky Lass Off-Pile Mine Soil	Arsenic	0.85	15	ppm	16/17	5.6	ppm	95% UCL
	Radium-226	0.72	7.5	pCi/g	16/16	1.5	pCi/g	95% UCL
White King Shallow Groundwater[2]	Arsenic	2.7	21,900	ppm	17/19	21,900	ppm	95%UCL
Lucky Lass Deep Bedrock Groundwater[2]	Arsenic	31.4	39.4	ppm	2/2	39.4	ppm	95% UCL

Key

pCi/g: Picocurie per gram
ppm: Parts per million
95% UCL: 95% Upper Confidence Limit
[1] Exposure point concentrations were calculated incorporating both surface soil and subsurface soil up to a depth of 6 feet
2 Groundwater exposure point concentrations are the same for current and future receptors.

Table 7-6

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current/Future Recreational User
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration [1]	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Auger Creek Surface Water	Arsenic	4.4	41.8	ppb	11/17	41.8	ppb	MAX
White King Pond Surface Water	Arsenic	10.2	128.0	ppb	4/4	128.0	ppb	MAX

Key

ppb: Parts per billion
MAX: Maximum Concentration

[1] Exposure point concentrations calculated using surface soil data, except for radionuclides, where a combination of surface and subsurface data were used.

Table 7-7

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current/Future Recreational User
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration [1]	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Auger Creek Sediment	Arsenic	25.4	159	ppm	5/5	159	ppm	MAX

Key

ppm: Parts per million
MAX: Maximum Concentration
[1] Sediment exposure point concentration are the same for current and future receptors

TABLE 7-8 –Exposure Parameter Values—Reasonable Maximum Exposure
White King/Lucky Lass Mines Site
Lakeview, Oregon
(Continued)

Parameter	Receptor: Adult Recreational User (Current/Future)	Child Recreational User (Current/Future)	Worker (Current/Future)	Resident Adult (Future)	Resident Child (Future)
Inhalation of Particulates					
IH (m^3/day)	20	20	20	20	20
ED (yrs)	24	6	25	24	6
EF (days/yr)	26	26	23	183	183
BW (kg)	70	15	70	70	15
AT (days)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)
Ingestion of Augur Creek Surface Water					
IR_w (L/day)	0.5	0.5	0.5	0.5	0.5
EF (days/yr)	13	13	4	13	13
ED (yrs)	24	6	25	24	6
BW (kg)	70	15	70	70	15
AT (days)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)
Incidental Ingestion of Mine Pit Water					
IR_w (L/day)	0.1	0.1	NA	0.1	0.1
EF (days/yr)	12	12	NA	24	24
ED (yrs)	24	6	NA	24	6
BW (kg)	70	15	NA	70	15
AT (days)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	NA	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)
Ingestion of Groundwater					
IR_w (L/day)	NA	NA	NA	2	1
EF (days/yr)	NA	NA	NA	350	350
ED (yrs)	NA	NA	NA	24	6
BW (kg)	NA	NA	NA	70	15
AT (days)	NA	NA	NA	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)

TABLE 7-8 (cont) -Exposure Parameter Values—Reasonable Maximum Exposure
White King/Lucky Lass Mines Site
Lakeview, Oregon

Parameter	Receptor				
	Adult Recreational User (Current/Future)	Child Recreational User (Current/Future)	Worker (Current/Future)	Resident Adult (Future)	Resident Child (Future)
Incidental Ingestion of Stockpile Materials and Soil					
IR_s (mg/day)	50	200	50	100	200
ED (yrs)	24	6	25	24	6
EF (days/yr)	26	26	23	183	183
BW (kg)	70	15	70	70	15
AT (days)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)
Incidental Ingestion of Augur Creek Sediment					
IR_s (mg/day)	50	200	50	100	200
ED (yrs)	24	6	25	24	6
EF (days/yr)	13	13	4	13	13
BW (kg)	70	15	70	70	15
AT (days)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)
Incidental Ingestion of Mine Pit Sediment					
IR_s (mg/day)	50	200	NA	100	200
ED (yrs)	24	6	NA	24	6
EF (days/yr)	12	12	NA	24	24
BW (kg)	70	15	NA	70	15
AT (days)	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)	NA	70x365 (carc.) EDx365 (noncarc.)	70x365 (carc.) EDx365 (noncarc.)
Inhalation of Radon Gas in Indoor Air					
IH (m^3/day)	NA	NA	NA	20	NA
ED (yrs)	NA	NA	NA	30	NA
EF (days/yr)	NA	NA	NA	365	NA
ET (hrs/day)	NA	NA	NA	16	NA

TABLE 7-8 (cont) –Exposure Parameter Values—Reasonable Maximum Exposure
White King/Lucky Lass Mines Site
Lakeview, Oregon
(Continued)

Parameter	Receptor				
	Adult Recreational User (Current/Future)	Child Recreational User (Current/Future)	Worker (Current/Future)	Resident Adult (Future)	Resident Child (Future)
Inhalation of Vapors from Groundwater					
tf (pCi/m^3 per pCi/L)	NA	NA	NA	0.5	0.5
External Exposure to Radionuclides in Soil					
ET (hr/day)	3	3	8	24	24
EF (days/yr)	26	26	23	350	350
ED (yrs)	24	6	9	24	6

NA - Not applicable
Carc. - Carcinogens
Noncarc. - Noncarcinogens

Table 7-9

Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal

Chemical of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence/Cancer Guideline Description	Source	Date (MM/DD/YYYY)
Arsenic	1.5E+00	1.5E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	2nd Quarter, 1996
Radium-226	3.0E-10	3.0E-10	risk/pCi	A	HEAST	1995

Pathway: Inhalation

Chemical of Concern	Unit Risk	Units	Inhalation Cancer Slope Factor	Units	Weight of Evidence/Cancer Guideline Description	Source	Date (MM/DD/YYYY)
Arsenic	4.3E-3	$(ug/m^3)^{-1}$	1.5E+1	$(mg/kg\text{-}day)^{-1}$	A	IRIS	2nd Quarter, 1996
Radium-226	—	—	2.8E-9	risk/pCi	A	HEAST	1995

Pathway: External (Radiation)

Chemical of Concern	Cancer Slope or Conversion Factor	Exposure Route	Units	Weight of Evidence/Cancer Guideline Description	Source	Date (MM/DD/YYYY)
Radium-226	6.7E-6	External	risk/pCi	A	HEAST	1995

Key

—: No information available
IRIS: Integrated Risk Information System, U.S. EPA
HEAST: Health Effects Assessment Summary Tables, U.S. EPA

EPA Group:

A - Human carcinogen
B1 - Probable human carcinogen - Indicates that limited human data are available
B2 - Probable human carcinogen - Indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

Table 7-10

Non-Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal

Chemical of Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Dermal RfD	Dermal RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (MM/DD/YYYY)
Arsenic	Chronic	3E-4	mg/kg-day	3E-4	mg/kg-day	skin	3	IRIS	2nd Quarter, 1996
Ra-226	—	—	—	—	—	—	—	—	—

Pathway: Inhalation

Chemical of Concern	Chronic/ Subchronic	Inhalation RfC	Inhalation RfC Units	Inhalation RfD	Inhalation RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (MM/DD/YYYY)
Arsenic	—	—	—	—	—	—	—	—	—
Radium-226	—	—	—	—	—	—	—	—	—

Key

—: No information available
IRIS: Integrated Risk Information System, U.S. EPA

Table 7-11

Risk Characterization Summary - Carcinogens

Scenario Timeframe: Current
Receptor Population: Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Soil	White King Soil	Surface Soil	Arsenic	6.36E-5	3.76E-7	N/A	N/A	6.40E-5
		Surface Soil	Radium-226	6.52E-7	3.54E-9	N/A	2.66E-4	2.67E-4
							Soil risk total=	3.3E-4
							Total Risk =	3.3E-4

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-12

Risk Characterization Summary - Carcinogens

Scenario Timeframe: Future
Receptor Population: Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Soil	White King Soil	Surface Soil	Arsenic	1.21E-4	7.14E-7	N/A	N/A	1.22E-4
		Surface Soil	Radium-226	1.33E-07	3.54E-9	N/A	5.42E-5	5.43E-5
							Soil risk total=	1.76E-4
							Total Risk =	1.76E-4

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-13

Risk Characterization Summary - Carcinogens

Scenario Timeframe: Future
Receptor Population: Recreational User
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Soil	White King/Lucky Lass Soil	Surface/Subsurface Soil	Arsenic	3.89E-4	9.04E-7	N/A	N/A	3.9E-4
		Surface/Subsurface Soil	Radium-226	5.99E-8	9.61E-10	N/A	2.29E-6	2.35E-6
							Soil risk total=	**3.92E-4**
Sediment	Auger Creek	Sediment	Arsenic	9.71E-6	N/A	N/A	N/A	9.71E-6
	White King Pond	Sediment	Arsenic	1.10E-5				1.10E-5
							Sediment risk total=	**2.07E-5**
Surface Water	Auger Creek	Surface Water	Arsenic	6.38E-6	N/A	N/A	N/A	6.38E-6
	White King Pond	Surface Water	Arsenic	3.61E-6	N/A	N/A	N/A	3.61E-6
							Surface-water risk total=	**9.99E-6**
							Total Risk =	**4.23E-4**

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-14

Risk Characterization Summary - Carcinogens

Scenario Timeframe: Current
Receptor Population: Recreational User
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Soil	White King/Lucky Lass Soil	Surface/Subsurface Soil	Arsenic	1.12E-4	4.76E-7	N/A	N/A	1.12E-4
		Surface/Subsurface Soil	Radium-226	1.77E-07	9.61E-10	N/A	6.77E-6	6.95E-6
							Soil risk total=	1.19E-4
Sediment	Auger Creek	Sediment	Arsenic	9.71E-6	N/A	N/A	N/A	9.71E-6
	White King Pond	Sediment	Arsenic	1.10E-5	N/A	N/A	N/A	1.10E-5
							Sediment risk total=	2.07E-5
Surface Water	Auger Creek	Surface Water	Arsenic	6.38E-6	N/A	N/A	N/A	6.38E-6
	White King Pond	Surface Water	Arsenic	3.61E-6	N/A	N/A	N/A	3.61E-6
							Surface-water risk total=	9.99E-06
							Total Risk =	1.5E-4

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-15
Risk Characterization Summary - Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Soil	White King Overburden Soil	Surface Soil	Arsenic	4.31E-3	5.45E-6	N/A	N/A	4.32E-3
		Surface Soil	Radium-226	3.83E-5	2.71E-8	N/A	4.49E-2	4.49E-2
							Soil Risk total=	4.9E-2
Groundwater	Shallow Groundwater	Tap Water	Arsenic	2.66E-1	N/A	N/A	N/A	2.66E-1
			Radon	N/A	1.36E-2	N/A	N/A	1.36E-2
							Groundwater Risk Total=	2.79E-1
Surface Water	Surface Water	White King Pond	Arsenic	6.18E-06	N/A	N/A	N/A	6.18E-6
			Radium-226	1.73E-08	N/A	N/A	N/A	1.73E-8
							Groundwater Risk Total=	6.2E-6
Sediment	Sediment	White King Pond	Arsenic	9.47E-6	N/A	N/A	N/A	9.47E-6
			Radium-226	2.42E-8	N/A	N/A	N/A	2.42E-8
							Sediment Risk Total=	9.49E-6
							Total Risk =	3.28E-1

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-16

Risk Characterization Summary - Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Soil	Lucky Lass Off-Pile Soil	Surface Soil	Arsenic	2.06E-6	N/A	N/A	N/A	2.06E-6
		Surface Soil	Radium-226	1.98E-7	8.61E-10	N/A	2.3E-4	2.3E-4
							Soil risk total=	2.32E-4
Groundwater	Lucky Lass Shallow Groundwater	Tap Water	Arsenic	5.92E-4	N/A	N/A	N/A	5.92E-4
			Radon	N/A	5.92E-4	N/A	N/A	5.93E-4
							Groundwater risk total=	1.18E-3
							Total Risk =	1.33E-3

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-18

Risk Characterization Summary - Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Soil	Lucky Lass Off-Pile Soil	Surface Soil	Arsenic	4.18E-6	N/A	N/A	N/A	4.18E-6
		Surface Soil	Radium-226	9.88E-8	8.61E-10	N/A	5.78E-5	5.78E-5
							Soil risk total=	6.2E-5
Groundwater	Lucky Lass Shallow Groundwater	Tap Water	Arsenic	3.45E-4	N/A	N/A	N/A	3.45E-4
			Radon		1.22-4			1.22E-4
							Groundwater risk total=	4.67E-4
							Total Risk =	5.2E-4

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-19

Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current
Receptor Population: Recreational User
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	White King Soil	Surface/Sub surface Soil	Arsenic	skin	2.9E+0	N/A	N/A	2.9E+0
							Soil Hazard Index Total =	2.9E+0
Sediment	Auger Creek	Sediment	Arsenic	skin	2.52E-1	N/A	N/A	2.52E-1
	White King Pond	Sediment	Arsenic	skin	2.86E-1	N/A	N/A	2.86E-1
	Lucky Lass Pond	Sediment	Arsenic	skin	9.79E-3	N/A	N/A	9.79E-3
							Sediment Hazard Index Total =	5.48E-1
Surface Water	Auger Creek	Surface Water	Arsenic	skin	1.65E-1	N/A	N/A	1.65E-1
	White King Pond	Surface Water	Arsenic	skin	9.35E-2	N/A	N/A	9.35E-2
	Lucky Lass Pond	Surface Water	Arsenic	skin	1.28E-2	N/A	N/A	1.28E-2
							Surface-Water Hazard Index Total =	2.71E-1
							Receptor Hazard Index =	3.7E+0

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-20

Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Recreational User
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	White King Soil	Surface/Subsurface Soil	Arsenic	skin	1.01E+1	N/A	N/A	1.01E+1
							Soil Hazard Index Total =	1.01+1
Sediment	Auger Creek	Sediment	Arsenic	skin	2.52E-1	N/A	N/A	2.52E-1
	White King Pond	Sediment	Arsenic	skin	2.86E-1	N/A	N/A	2.86E-1
	Lucky Lass pond	Sediment	Arsenic	skin	9.79E-3	N/A	N/A	9.79E-3
							Sediment Hazard Index Total =	5.48E-1
Surface Water	Auger Creek	Surface Water	Arsenic	skin	1.65E-1	N/A	N/A	1.65E-1
	White King Pond	Surface Water	Arsenic	skin	9.35E-2	N/A	N/A	9.35E-2
	Lucky Lass Pond	Surface Water	Arsenic	skin	1.28E-2	N/A	N/A	1.28E-2
							Surface-Water Hazard Index Total =	2.71E-1
							Receptor Hazard Index =	10.6E+0

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-21

Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	White King Soil	Surface Soil	Arsenic	skin	2.79E+1	N/A	N/A	2.79E+1
							Soil Hazard Index Total=	2.79E+1
Groundwater	Whiter King Shallow Groundwater	Tap Water	Arsenic	skin	2.0E+3			2.0E+3
							Groundwater Hazard Index Total=	2.0E+3
							Receptor Hazard Index =	2.03E+3

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-22

Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Lucky Lass Off-Pile Soil	Surface Soil	Arsenic	skin	1.34E-2	N/A	N/A	1.34E-2
							Soil Hazard Index Total=	1.34E-2
Groundwater	Deep Bedrock Groundwater	Tap Water	Arsenic	skin	3.84E+0	N/A	N/A	3.8E+0
							Ground water Hazard Index Total=	3.8E+0
Surface Water	Lucky Lass Pond	Surface Water	Arsenic	skin	5.48E-3	N/A	N/A	5.8E-3
							Surface Water Hazard Index Total=	5.8E-3
Sediment	Lucky Lass Pond	Sediment	Arsenic	skin	2.10E-3	N/A	N/A	2.10E-3
							Sediment Hazard Index Total=	2.10E-3
							Receptor Hazard Index =	3.82E+0

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-23

Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	White King Soil	Surface Soil	Arsenic	skin	2.61E+2	N/A	N/A	2.61E+2
							Surface Soil Hazard Index Total=	2.61E+2
Groundwater	White King Shallow Groundwater	Tap Water	Arsenic	skin	4.67E+3			4.67E+3
							Groundwater Hazard Index Total=	4.67E+3
							Receptor Hazard Index =	4.93E+3

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-24

Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Lucky Lass Off-Pile Soil	Surface Soil	Arsenic	skin	1.25E-1	N/A	N/A	1.25E-1
							Soil Hazard Index Total =	1.25-1
Groundwater	Deep Bedrock Groundwater	Tap Water	Arsenic	skin	8.95E+0	N/A	N/A	8.95E+0
							Groundwater Hazard Index Total=	8.95E+0
							Receptor Hazard Index =	9.7E+0

Key

N/A: Route of exposure is not applicable to this medium.

Table 7-25
Occurrence, Distribution, and Selection of Chemicals of Concern (COC) Ecological Risk Assessment

Exposure Medium: Sediment - Auger Creek

Chemical of Potential Concern	Minimum Conc.[1] (ppm)	Maximum Conc.[1] (ppm)	Mean Conc. (ppm)	95 % UCL of the Mean [2] (ppm)	Background Conc. (ppm)	Screening Toxicity Value (ppm)	Screening Toxicity Value Source [3]	HQ Value [4]	COC Flag (Y or N)
Arsenic	25.4	159	103.6	159	4.2	6	Ont. LEL	2.65E+01	Y
Manganese	359	6090	2735	4459	1610	460	Ont. LEL	1.32E+01	Y

Key
Conc. = Concentration
—: No information available

Notes
[1] Minimum/ maximum detected concentration above the sample quantitation limit (SQL).
[2] The 95% Upper Confidence Limit (UCL) represents the RME concentration.
[3] Ont LEL = Ontario Lowest Effects Level Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. D. Persaud, R. Jaagumagi, and A. Hayton. Ontario Ministry of the Environment, Ontario, August 1993.
[4] Hazard Quotient (HQ) is defined as Maximum Concentration/ Screening Toxicity Value.

Table 7-26
Occurrence, Distribution, and Selection of Chemicals of Concern (COC) Ecological Risk Assessment

Exposure Medium: Sediment - White King

Chemical of Potential Concern	Minimum Conc.[1] (ppm)	Maximum Conc.[1] (ppm)	Mean Conc. (ppm)	95 % UCL of the Mean [2] (ppm)	Background Conc. (ppm)	Screening Toxicity Value (ppm)	Screening Toxicity Value Source [3]	HQ Value [4]	COC Flag (Y or N)
Arsenic	196	196	196	196	—	6	Ont. LEL	3.27E+01	Y
Manganese	388	388	388	388	—	460	Ont. LEL	0.843	Y
Mercury	.97	.97	.97	.97	—	.20	Ont. LEL	4.85E+00	Y

Key
Conc. = Concentration
— : No information available

Notes
[1] Minimum/ maximum detected concentration above the sample quantitation limit (SQL).
[2] The 95% Upper Confidence Limit (UCL) represents the RME concentration.
[3] Ont LEL = Ontario Lowest Effects Level Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. D. Persaud, R. Jaagumagi, and A. Hayton. Ontario Ministry of the Environment, Ontario, August 1993.
[4] Hazard Quotient (HQ) is defined as Maximum Concentration/ Screening Toxicity Value.

Table 7-27
Occurrence, Distribution, and Selection of Chemicals of Concern (COC) Ecological Risk Assessment

Exposure Medium: Surface water - White King Pond

Chemical of Potential Concern	Minimum Conc.[1] (ppm)	Maximum Conc.[1] (ppm)	Mean Conc. (ppm)	95 % UCL of the Mean [2] (ppm)	Background Conc. (ppm)	Screening Toxicity Value (ppm)	Screening Toxicity Value Source [3]	HQ Value [4]	COC Flag (Y or N)
Aluminum	NA	4.01	3.62	4.41	N/A	0.2	EPA SMCL & Aquatic Effects Level	20	Y
Arsenic	NA	0.128	.072	.14	.01	0.048	Oregon Water Quality Critera LOEL	2.7E+0	Y

Key
Conc. = Concentration
—: No information available

Notes
[1] Minimum/ maximum detected concentration above the sample quantitation limit (SQL).
[2] The 95% Upper Confidence Limit (UCL) represents the RME concentration.
[3] SMCL = Secondary MCL
[4] Hazard Quotient (HQ) is defined as Maximum Concentration/ Screening Toxicity Value.

Table 7-28
Occurrence, Distribution, and Selection of Chemicals of Concern (COC) Ecological Risk Assessment

Exposure Medium: Surface/Subsurface Soil - White King

Chemical of Potential Concern	Minimum Conc.[1] (ppm)	Maximum Conc.[1] (ppm)	Mean Conc. (ppm)	95 % UCL of the Mean [2] (ppm)	Background Conc. (ppm)	Screening Toxicity Value (ppm)	Screening Toxicity Value Source	HQ Value [4]	COC Flag (Y or N)
Arsenic		13,794	1.04E+ 3	1.634E+3		10.0	ORNL [3]	1.38E+ 03	Y
Antimony		249E+0	4.133E+ 1	9.018E+1		1.40E-01	Chronic NOAEL[5]	4.84E+0 2	Y
Selenium		68.10E+0	4.747E+ 0	9.404E+0		1.0E+0	ORNL [3]	6.81E+0 1	Y
Mercury		64.30E+0	3.473E+ 0	6.091E+0		.30E+0	ORNL [3]	2.14E+0 2	Y

Key
Conc. = Concentration
—: No information available

Notes
[1] Minimum/ maximum detected concentration above the sample quantitation limit (SQL).
[2] The 95% Upper Confidence Limit (UCL) represents the RME concentration.
[3] Oak Ridge National Laboratory data file for plants - Will and Suter, 1994
[4] Hazard Quotient (HQ) is defined as Maximum Concentration/ Screening Toxicity Value.
[5] Schroeder et al. 1970

Table 7-29 -Summary of Ecological Hazard Quotients and Associated Receptor Effects
White King/Lucky Lass Mining Site, Lakeview, Oregon
(continued)

	White King				Lucky Lass				Augur Creek		Receptor
Receptor/Analyte	SS	SBS	SD	SW	SS	SBS	SD	SW	SD	SW	Effects
Aquatic Invertebrates											
Arsenic			32.7				1.1		26.5		Decreased tolerance by benthic organisms
Cadmium									3		Decreased tolerance by benthic organisms
Copper							2				Decreased tolerance by benthic organisms
Iron			1.6				1.6				Decreased tolerance by benthic organisms
Manganese							1.6		13.2		Decreased tolerance by benthic organisms
Mercury			4.9								Decreased tolerance by benthic organisms
Nickel			1.1				1.1				Decreased tolerance by benthic organisms
Silver							1.4				Decreased tolerance by benthic organisms
Zinc									2.2		Decreased tolerance by benthic organisms
Cumulative Hazard			**40**				**9**		**45**		
Aquatic Biota											
Arsenic				2.7							Increased long-term sublethality in aquatic organisms
Iron				1.4				3			Increased long-term sublethality in aquatic organisms
Lead								1.8		6.9	Increased long-term sublethality in aquatic organisms
Mercury										21.7	Increased long-term sublethality in aquatic organisms
Cumulative Hazard				**4.1**				**4.8**		**28.6**	

Note: Unbolded numbers represent the hazard quotient value for the presented receptor, analyte, location, and medium. Bolded numbers represent the cumulative hazard quotient or hazard index for the presented receptor, location, and medium. A blank cell indicates that either the hazard quotient was less than 1.0 or no hazard quotients were calculated for that receptor and medium. Receptor effects were taken from the effect summary tables presented for each receptor (D.3-8, D.3-9, D.3-10, D.3-11, D.3-12/13). Effects for the community groups (i.e., plants, invertebrates, biota) had to be expressed as group effects rather than as individual effects as presented for the grouse, crane, and shrew.

SS - Surface soil
SD - Sediment
SBS - Subsurface soil
SW - Surface water

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Table 7-29 --Summary of Ecological Hazard Quotients and Associated Receptor Effects White King/Lucky Lass Mining Site, Lakeview, Oregon

	White King				Lucky Lass				Augur Creek		Receptor
Receptor /Analyte	SS	SBS	SD	SW	SS	SBS	SD	SW	SD	SW	Effects
Blue Grouse											
Arsenic	8.9	29.7									Behavioral abnormalities
Lead	1.7	6.4									Reproductive and histopathological effects
Mercury	1.8	22.3									Increased mortality
Selenium	26.5										Reproductive effects
Cumulative Hazard	**38.9**	**58.4**									
Greater Sandhill Crane											
Aluminum			51.8				56.3				Increased body weight/decreased growth/abnormal egg production
Iron			11.8				12.3				Increased mortality and decreased bone ash
Magnesium			1.4				5.5				Decrease in body weight and bone ash
Vanadium			2.4				1.9				Reproductive effects
Cumulative Hazard			**67.4**				**76**				
Vagrant Shrew											
Antimony	87.5	48.4									Increased mortality
Arsenic	310	1,030			1.1						Increased mortality/decreased body weight
Calcium					3.5						Changes in serum electrolytes and blood pressure
Lead	25,000	93,500									Genotoxicity or embryotoxicity
Selenium	49.4										Abnormal fetal growth
Thallium	1.1	3.6									Increased mortality
Cumulative Hazard	**25,448**	**94,582**			**4.6**						
Terrestrial Plants											
Antimony	9	49.8									Reduced or abnormal plant growth
Arsenic	414	1,380			1.5						Reduced or abnormal plant growth
Beryllium		1.1									Reduced or abnormal plant growth
Lead	2.8	10.3									Reduced or abnormal plant growth
Mercury	17.7	214									Reduced or abnormal plant growth
Selenium	68.1										Reduced or abnormal plant growth
Silver		2.1			3.4						Reduced or abnormal plant growth
Thallium	2.3	8									Reduced or abnormal plant growth
Cumulative Hazard	**514**	**1,665**			**5**						

TABLE 8-1

WATER QUALITY CRITERIA SUMMARY

(Applicable to all Basins)[1]

The concentration for each compound listed in this chart is a criteria or guidance value* not to be exceeded in waters of the state for the protection of aquatic life and human health. Specific descriptions of each compound and an explanation of values are included in Quality Criteria for Water (1986). Selecting values for regulatory purposes will depend on the most sensitive beneficial use to be protected, and what level of protection is necessary for aquatic life and human health.

Compound Name (or Class)	Priority Pollutant	Carcinogen	Concentration in Micrograms Per Liter for Protection of Aquatic Life				Concentration in Units Per Liter for Protection of Human Health		
			Fresh Acute Criteria	Fresh Chronic Criteria	Marine Acute Criteria	Marine Chronic Criteria	Water and Fish Ingestion	Fish Consumption Only	Drinking Water M.C.L.
ACENAPTHENE	Y	N	*1,700.	*520.	*970.	*710.			
ACROLEIN	Y	N	*68.	*21.	*55.		320.ug	780.ug	
ACRYLONITRILE	Y	Y	*7,550.	*2,600.			0.058ug**	0.65ug**	
ALDRIN	Y	Y	3.0		1.3		0.074ng**	0.079ng**	
ALKALINITY	N	N		20,000					
AMMONIA	N	N	CRITERIA ARE pH AND TEMPERATURE DEPENDENT — SEE DOCUMENT USEPA JANUARY 1985 (Fresh Water) CRITERIA ARE pH AND TEMPERATURE DEPENDENT — SEE DOCUMENT USEPA APRIL 1989 (Marine Water)						
ANTIMONY	Y	N	*9,000.	*1,600.			146.ug	45,000.ug	
ARSENIC	Y	Y					2.2ng**	17.5ng**	0.05mg
ARSENIC (PENT)	Y	Y	*850.	*48.	*2,319.	*13.			
ARSENIC (TRI)	Y	Y	360.	190.	69.	36.			
ASBESTOS	Y	Y					30K f/L**		
BARIUM	N	N					1.mg		1.0mg
BENZENE	Y	Y	*5,300.		*5,100.	*700.	0.66ug**	40.ug**	
BENZIDINE	Y	Y	*2,500.				0.12ng	0.53ng**	
BERYLLIUM	Y	Y	*130.	*5.3			6.8ng**	117.ng**	
BHC	Y	N	*100.		*0.34				
CADMIUM	Y	N	3.9+	1.1+	43.	9.3	10.ug		0.010mg
CARBON TETRACHLORIDE	Y	Y	*35,200.		*50,000.		0.4ug**	6.94ug**	
CHLORDANE	Y	Y	2.4	0.0043	0.09	0.004	0.46ng**	0.48ng**	
CHLORIDE	N	N	860 mg/L	230 mg/L					
CHLORINATED BENZENES	Y	Y	*250	*50.	*160.	*129.	488.ug		
CHLORINATED NAPHTHALENES	Y	N	*1,600.		*7.5				
CHLORINE	N	N	19.	11.	13.	7.5			
CHLOROALKYL ETHERS	Y	N	*238,000.						
CHLOROETHYL ETHER (BIS-2)	Y	Y					0.03ug	1.36ug**	
CHLOROFORM	Y	Y	*28,900.	*1,240.			0.19ug**	15.7ug**	
CHLOROISOPROPYL ETHER (BIS-2)	Y	N					34.7ug	4.36mg	

WATER QUALITY CRITERIA SUMMARY (Continued)

Compound Name (or Class)	Priority Pollutant	Carcinogen	Concentration in Micrograms Per Liter for Protection of Aquatic Life				Concentration in Units Per Liter for Protection of Human Health		
			Fresh Acute Criteria	Fresh Chronic Criteria	Marine Acute Criteria	Marine Chronic Criteria	Water and Fish Ingestion	Fish Consumption Only	Drinking Water M.C.L.
CHLOROMETHYL ETHER (BIS)	N	Y					0.00000376ng**	0.00184ug**	
CHLOROPHENOL 2	Y	N	*4,380.	*2,000.					
CHLOROPHENOL 4	N	N			*29,700.				
CHLOROPHENOXY HERBICIDES (2,4,5,-TP)	N	N					10.ug		
CHLOROPHENOXY HERBICIDES (2,4-D)	N	N					100.ug		
CHLORPYRIFOS	N	N	0.083	0.041	0.011	0.0056			
CHLORO-4 METHYL-3 PHENOL	N	N	*30.						
CHROMIUM (HEX)	Y	N	16.	11.	1,100	50.	50.ug		0.05mg
CHROMIUM (TRI)	N	N	1,700.+	210.+	*10,300		170.mg	3,433.mg	0.05mg
COPPER	Y	N	18.+	12.+	2.9	2.9			
CYANIDE	Y	N	22.	5.2	1.	1.	200.ug		
DDT	Y	Y	1.1	0.001	0.13	0.001	0.024ng**	0.024ng**	
DDT METABOLITE (DDE)	Y	Y	*1,050.		*14.				
DDT METABOLITE (TDE)	Y	Y	*0.06		*3.6				
DEMETON	Y	N		0.1		0.1			
DIBUTYLPHTHALATE	Y	N					35.mg	154.mg	
DICHLOROBENZENES	Y	N	*1,120.	*763.	*1,970.		400.ug	2.6mg	
DICHLOROBENZIDINE	Y	Y					0.01ug**	0.020ug**	
DICHLOROETHANE 1,2	Y	Y	*118,000.	*20,000.	*113,000.		0.94ug**	243.ug**	
DICHLOROETHYLENES	Y	Y	*11,600.		*224,000.		0.033ug**	1.85ug**	
DICHLOROPHENOL 2,4	N	N	*2,020.	*365.			3.09mg		
DICHLOROPROPANE	Y	N	*23,000.	*5,700.	*10,300.	*3,040.			
DICHLOROPROPENE	Y	N	*6,060.	*244.	*790.		87.ug	14.1mg	
DIELDRIN	Y	Y	2.5	0.0019	0.71	.0019	0.071ng**	0.076ng**	
DIETHYLPHTHALATE	Y	N					350.mg	1.8g	
DIMETHYL PHENOL 2,4	Y	N	*2,120.						
DIMETHYL PHTHALATE	Y	N					313.mg	2.9g	
DINITROTOLUENE 2,4	N	Y					0.11ug**	9.1ug**	
DINITROTOLUENE	Y	N					70.ug	14.3mg	
DINITROTOLUENE	N	Y	*330.	*230.	*590.	*370.			
DINITRO-O-CRESOL 2,4	Y	N					13.4g	765.ug	
DIOXIN (2,3,7,8-TCDD)	Y	Y	*0.01	*38 pg/L			0.000013ng**	0.000014ng**	
DIPHENYLHYDRAZINE	Y	N					42.ng**	0.56ug**	

WATER QUALITY CRITERIA SUMMARY (Continued)

Compound Name (or Class)	Priority Pollutant	Carcinogen	Concentration in Micrograms Per Liter for Protection of Aquatic Life				Concentration in Units Per Liter for Protection of Human Health		
			Fresh Acute Criteria	Fresh Chronic Criteria	Marine Acute Criteria	Marine Chronic Criteria	Water and Fish Ingestion	Fish Consumption Only	Drinking Water M.C.L.
DIPHENYLHYDRAZINE 1,2	Y	N	*270.						
DI-2-ETHYLHEXYL PHTHALATE	Y	N					15.mg	50.mg	
ENDOSULFAN	Y	N	0.22	0.056	0.034	0.0087	74.ug	159.ug	
ENDRIN	Y	N	0.18	0.0023	0.037	0.0023	1.ug		0.0002mg
ETHYLBENZENE	Y	N	*32,000.		*430.		1.4mg	3.28mg	
FLUORANTHENE	Y	N	*3,980.		*40.	*16.	42.ug	54.ug	
GUTHION	N	N		0.01		0.01			
HALOETHERS	Y	N	*360.	*122.					
HALOMETHANES	Y	Y	*11,000.		*12,000.	*6,400.	0.19ug**	15.7ug**	
HEPTACHLOR	Y	Y	0.52	0.0038	0.053	0.0036	0.28ng**	0.29ng**	
HEXACHLOROETHANE	N	Y	*980.	*540.	*940.		1.9ug	8.74ug	
HEXACHLOROBENZENE	Y	N					0.72ng**	0.74ng**	
HEXACHLOROBUTADIENE	Y	Y	*90.	*9.3	*32.		0.45ug**	50.ug**	
HEXACHLOROCYCLOHEXANE (LINDANE)	Y	Y	2.0	0.08	0.16				0.004mg
HEXACHLOROCYCLOHEXANE-ALPHA	Y	Y					9.2ng**	31.ng**	
HEXACHLOROCYCLOHEXANE-BETA	Y	Y					16.3ng**	54.7ng**	
HEXACHLOROCYCLOHEXANE-GAMA	Y	Y					18.6ng**	62.5ng**	
HEXACHLOROCYCLOHEXANE-TECHNICAL	Y	Y					12.3ng**	41.4ng**	
HEXACHLOROCYCLOPENTADIENE	Y	N	*7.	*5.2	*7.		206.ug		
IRON	N	N		1,000.			0.3mg		
ISOPHORONE	Y	N	*117,000.		*12,900.		5.2mg	520.mg	
LEAD	Y	N	82.+	3.2+	140.	5.6	50.ug		0.05mg
MALATHION	N	N		0.1		0.1			
MANGANESE	N	N					50.ug	100.ug	
MERCURY	Y	N	2.4	0.012	2.1	0.025	144.ng	146.ng	0.002mg
METHOXYCHLOR	N	N		0.03		0.03	100.ug		0.1mg
MIREX	N	N		0.001		0.001			
MONOCHLOROBENZENE	Y	N					488.ug		
NAPHTHALENE	Y	N	*2,300.	*620.	*2,350.				
NICKEL	Y	N	1,400.+	160+	75	8.3	13.4ug	100.ug	
NITRATES	N	N					10.mg		10.mg
NITROBENZENE	Y	N	*27,000.		*6,680.		19.8mg		
NITROPHENOLS	Y	N	*230.	*150.	*4,850.				

WATER QUALITY CRITERIA SUMMARY (Continued)

Compound Name (or Class)	Priority Pollutant	Carcinogen	Concentration in Micrograms Per Liter for Protection of Aquatic Life				Concentration in Units Per Liter for Protection of Human Health		
			Fresh Acute Criteria	Fresh Chronic Criteria	Marine Acute Criteria	Marine Chronic Criteria	Water and Fish Ingestion	Fish Consumption Only	Drinking Water M.C.L.
NITROSAMINES	Y	Y	*5,850.		*3,300,000		0.8ng**	1,240.ng**	
NITROSODIBUTYLAMINE N	Y	Y					6.4ng**	587.ng**	
NITROSODIETHYLAMINE N	Y	Y					0.8ng**	1,240.ng**	
NITROSODIMETHYLAMINE N	Y	Y					1.4ng**	16,000.ng**	
NITROSODIPHENYLAMINE N	Y	Y					4,900.ng**	16,100.ng**	
NITROSOPYRROLIDINE N	Y	Y					16.ng**	91,900.ng**	
PARATHION	N	N	0.065	0.013					
PCB's	Y	Y	2.0	0.014	10.	0.03	0.079ng**	0.079ng**	
PENTACHLORINATED ETHANES	N	N	*7,240.	*1,100.	*390.	*281.			
PENTACHLOROBENZENE	N	N					74.ug	85.ug	
PENTACHLOROPHENOL	Y	N	***20.	***13.	13.	*7.9	1.01mg		
PHENOL	Y	N	*10,200.	*2,560.	*5,800.		3.5mg		
PHOSPHORUS ELEMENTAL	N	N				0.1			
PHTHALATE ESTERS	Y	N	*940.	*3.	*2,944.	*3.4			
POLYNUCLEAR AROMATIC HYDRO-CARBONS	Y	Y			*300.		2.8ng**	31.1ng**	
SELENIUM	Y	N	260.	35.	410.	54.	10.ug		0.01mg
SILVER	Y	N	4.1+	0.12	2.3		50.ug		0.05mg
SULFIDE-HYDROGEN SULFIDE	N	N		2.		2.			
TETRACHLORINATED ETHANES	Y	N	*9,320.						
TETRACHLOROBENZENE 1,2,4,5	Y	N					38.ug	48.ug	
TETRACHLOROETHANE 1,1,2,2	Y	Y		*2,400.	*9,020.		0.17ug**	10.7ug**	
TETRACHLOROETHANES	Y	N	*9,320.						
TETRACHLOROETHYLENE	Y	Y	*5,280.	*840.	*10,200.	*450.	0.8ug**	8.85ug**	
TETRACHLOROPHENOL 2,3,5,6	Y	N				*440.			
THALLIUM	Y	N	*1,400.	*40.	*2,130.		13.ug	48.ug	
TOLUENE	Y	N	*17,500.		*6,300.	*5,000.	14.3mg	424.mg	
TOXAPHENE	Y	Y	0.73	0.0002	0.21	0.0002	0.71ng**	0.73ng**	0.005mg
TRICHLORINATED EHANES	Y	Y	*18,000.						
TRICHLOROETHANE 1,1,1	Y	N			*31,2000.		18.4mg	1.03g	
TRICHLOROETHANE 1,1,2	Y	Y		*9,400.			0.6ug**	41.8ug**	
TRICHLOROETHYLENE	Y	Y	*45,000.	*21,900.	*2,000.		2.7ug**	80.7ug**	
TRICHLOROPHENOL 2,4,5	N	N					2,600.ug		
TRICHLOROPHENOL 2,4,6	Y	Y		*970.			1.2ug**	3.6ug**	

WATER QUALITY CRITERIA SUMMARY (Continued)

Compound Name (or Class)	Priority Pollutant	Carcinogen	Concentration in Micrograms Per Liter for Protection of Aquatic Life				Concentration in Units Per Liter for Protection of Human Health		
			Fresh Acute Criteria	Fresh Chronic Criteria	Marine Acute Criteria	Marine Chronic Criteria	Water and Fish Ingestion	Fish Consumption Only	Drinking Water M.C.L.
VINYL CHLORIDE	Y	Y					2.ug**	525.ug**	
ZINC	Y	N	120.+	110+	95	86			

MEANING OF SYMBOLS:

g = grams
mg = milligrams
ug = micrograms
ng = nanograms
pg = picograms
f = fibers
Y = Yes
N = No

M.C.L. = Maximum Contaminant Level

\+ = Hardness Dependent Criteria (100 mg/L used).

* = Insufficient data to develop criteria; value presented is the L.O.E.L. — Lower Observed Effect Level.

** = Human health criteria for carcinogens reported for three risk levels. Value presented is the 10-6 risk level, which means the probability of one concern case per million people at the stated concentration.

*** = pH Dependent Criteria (7.8 pH used).

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1 = Values in Table 20 are applicable to all basins as follows:

Basin	Rule	Basin	Rule
North Coast	340-41-205(p)	Umatilla	340-41-645(p)
Mid Coast	340-41-245(p)	Walla Walla	340-41-685(p)
Umpqua	340-41-285(p)	Grande Ronde	340-41-725(p)
South Coast	340-41-325(p)	Powder	340-41-765(p)
Rogue	340-41-365(p)	Malheur River	340-41-805(p)
Williamette	340-41-445(p)	Owyhee	340-41-845(p)
Sandy	340-41-485(p)	Malheur Lake	340-41-885(p)
Hood	340-41-525(p)	Goose & Summer Lakes	340-41-925(p)
Deschutes	340-41-565(p)	Klamath	340-41-965(p)
John Day	340-41-605(p)		

Water and Fish Ingestion

Values represent the maximum ambient water concentration for consumption of both contaminated water and fish or other aquatic organisms.

Fish Ingestion

Values represent the maximum ambient water concentration for consumption of fish or other aquatic organisms.

SA\Table\WH5307.D

TABLE 9-1

Comparison of White King Pond Water Quality Following In-Situ Treatment with PRG and Ambient Water Quality Criteria (AWQC)
White King/Lucky Lass Mines Site
Lakeview, Oregon

Analytes	Preliminary Remediation Goals	AWQC* Freshwater Chronic	White King Pond Average Dissolved Concentration[d]
PH	6.5 - 9.0	7.0 - 9.0	7.4
Total Inorganics (mg/L)			
Aluminum	0.2[e]	N/A	0.078
Antimony	NE	1.6	0.025 U
Arsenic	0.036[e]/0.033[f]	0.19[a]	0.014
Barium	NE	N/A	0.020
Beryllium	NE	0.0053[b]	0.0017 U
Cadmium	NE	0.0011[c]	0.0017 U
Chromium	NE	0.011	0.0054 U
Cobalt	NE	N/A	0.026
Copper	NE	0.012[c]	0.0058 U
Iron	NE	1.0	0.16 U
Lead	NE	0.0032[c]	0.0065 U
Manganese	NE	N/A	0.58
Mercury	NE	0.000012	0.000053 U
Nickel	NE	0.16[c]	0.045
Selenium	NE	0.035	0.0059 U
Silver	NE	0.00012	0.0057 U
Thallium	NE	0.040[c]	0.0097 U
Vanadium	NE	N/A	0.0028 U
Zinc	NE	0.11[c]	0.049

* EPA, 1986, Oregon Regulation 340.41; Ambient Water Quality Criteria. These criteria are provided for comparison purposes only. Basin standards may have been developed to address uses and exposures that are different from those associated with White King Pond.

N/A – Not available.
NE – Not established.

[a] Trivalent arsenic standard is used in lieu of total arsenic standard.
[b] Insufficient data to develop criteria; value presented is the Lowest Observed Effects Level.
[c] Hardness dependent criteria (100 mg/l used).
[d] Dissolved concentrations are used for comparison because the total analyses are not relevant as risk is related only to dissolved arsenic in water (WESTON, 1999b).
[e] PRG for White King Mine pond water.
[f] PRG for Augur Creek surface water.

U - Undetected.

TABLE 10-1

DETAILED ANALYSIS OF ALTERNATIVES - COST SUMMARY
WHITE KING/LUCK LASS MINES SITES
LAKEVIEW, OREGON

Alternatives	Capital/Construction Cost	Annual O&M Cost	Present Worth of 30 Year O&M Cost	PW of Incremental Cost for Perpetual Care	Total Present Worth Cost (30 year O&M)
White King Mine Stockpile					
SP-2[a]	$509,000	$36,000	$447,000	$67,000	$956,000
SP-3a[a]	$4,316,000	$68,000	$844,000	$127,000	$5,160,000
SP-3b[a]	$6,249,000	$54,000	$670,000	$101,000	$6,919,000
SP-4a[b]	$10,828,000	$55,000	$682,000	$104,000	$11,510,000
SP-4d[b]	$11,314,000	$55,000	$682,000	$104,000	$11,996,000
SP-5[b]	$26,116,000	$61,300	$724,000	$152,000	$26,840,000
White King Pond Water					
WKPW-2	$58,000	$18,000	$223,000	$34,000	$281,000
WKPW-3	$58,000	$55,000	$682,000	$104,000	$740,000
WKPW-4	$1,624,000	$0	$0	$0	$1,624,000
WKPW-5a	$1,664,000	$0	$0	$0	$1,664,000
WKPW-5b	$891,000	$0	$0	$0	$891,000
WKPW-6a	$1,731,000	$0	$0	$0	$1,731,000
WKPW-6b	$1,011,000	$0	$0	$0	$1,011,000
Lucky Lass Mine Stockpiles					
LL-2	$169,000	$15,000	$186,000	$28,000	$355,000
LL-3	$349,000	$15,000	$186,000	$28,000	$535,000
LL-4[c]	$2,656,000	$9,000	$112,000	$17,000	$2,768,000

Notes:

[a]Implementing these alternatives would also require implementing WKPW-2 or -3

[b]Implementing these alternatives would also require implementing WKPW-4, 5a, 5b, 6a, or 6b

[c]Inqremental cost of moving Lucky Lass stockpiles and combining with the Alternative SP-5.

Table 11-1

WHITE KING MINE WASTE STOCKPILES Alternative SP- 3b (Revised Weston Estimate)

Captial Costs for SP-3b

Description	Quantity	Unit	Unit Rate	Total Cost
Mobilization/Demobilization	1	Job	$ 29,000.00	$ 29,000
Sub-Total				**$ 29,000**
Site Preparation/Improvements				
Temporary Facilities	1	Job	$ 14,000.00	$ 14,000
Haul Roads	1	Job	$ 28,000.00	$ 28,000
USFS Road Improvements	1	Job	$ 30,000.00	$ 30,000
Environmental Controls	1	Job	$ 32,000.00	$ 32,000
Sub-Total				**$ 104,000**
Institutional Controls				
Physical restrictions	6,000	LF	$ 20.00	$ 120,000
Land use Restrictions	4	Parcel	$ 10,000.00	$ 40,000
Monitoring well installation	80	LF	$ 90.00	$ 7,200
Sub-Total				**$ 167,200**
Cover & Consolidation on Protore Stockpile				
Excavate & place Protore off-pile & soil for 25' setback from creek	137,955	CY	$ 3.00	$ 413,865
Excavate & place overburden stockpile	455,000	CY	$ 4.00	$ 1,820,000
Cover:				
Vegetation	21	Acres	$ 2,500.00	$ 52,500
Top soil	8,181	CY	$ 10.00	$ 81,810
Cover soil	40,907	CY	$ 6.00	$ 245,442
Barrier - Erosion resistant rock	16,363	CY	$ 14.00	$ 229,082
Restoration of USFS Borrow Source	2	Acres	$ 7,000.00	$ 14,000
Sub-Total				**$ 2,856,699**
Temporary & Final Reclamation				
Temp Reclamation following 1st Const season				
Temp Regrading & Erosion control at overburden stockpile	26	Acres	$ 1,000.00	$ 26,000
Temp Regrading & Erosion control at Protore stockpile	21	Acres	$ 1,000.00	$ 21,000
Temp Regrading & Erosion control in off pile areas	21	Acres	$ 1,000.00	$ 21,000
Final Reclamation following 1st Const season				
Final Regrading & Vegetation of overburden stockpile	26	Acres	$ 7,000.00	$ 182,000
Temp Regrading & Vegetation on Off pile areas	21	Acres	$ 7,000.00	$ 147,000
Sub-Total				**$ 397,000**
Stormwater Management System				
French Drain (see attached estimate)	1,800	LF	$ 60.00	$ 108,000
Drainage Swales (4' wide) total 2,700 LF				
Excavation	420	CY	$ 3.00	$ 1,260
Geotextile (10 oz/sy)	1,500	SY	$ 1.35	$ 2,025
Rip Rap (6"thick)	250	CY	$ 14.00	$ 3,500
Drainage Swales (8' wide) total 2,700 LF				
Excavation	1,200	CY	$ 3.00	$ 3,600
Geotextile (10 oz/sy)	3,000	SY	$ 1.35	$ 4,050
Rip Rap (8"thick)	700	CY	$ 14.00	$ 9,800

Table 11-1

WHITE KING MINE WASTE STOCKPILES Alternative SP- 3b (Revised Weston Estimate)

Description	Quantity	Unit	Unit Rate	Total Cost
Sub-Total				$ **132,235**
Construction Cost Sub-Total				$ **3,686,134**
Engineering/Design (6% of Const. Cost)	1	Job	$ 221,168.00	$ 221,168
Sub-Total				$ **221,168**
Contractor Procurement(s)	1	Job	$ 50,000.00	$ 50,000
Sub-Total				$ **50,000**
Local Requirements	1	Job	$ 25,000.00	$ 25,000
Sub-Total				$ **25,000**
Construction Management (2 Construction Seasons)				
Resident Engineering	2,640	Hour	$ 80.00	$ 211,200
Construction Manager	2,640	Hour	$ 80.00	$ 211,200
Health & Safety Officer	2,640	Hour	$ 80.00	$ 211,200
Assistant to Health Physicist	1,440	Hour	$ 50.00	$ 72,000
Confirmation Sampling	1	Job	$ 7,500.00	$ 7,500
Construction Technician (Compaction Testing)	768	Hour	$ 45.00	$ 34,560
Cover QA/QC Testing	21	Acre	$ 4,000.00	$ 84,000
Surveying	1	Job	$ 15,000.00	$ 15,000
Health & Safety Monitoring	1	Job	$ 45,500.00	$ 45,500
Post Const Documentation & Certification	1	Job	$ 36,000.00	$ 36,000
Home Office Allocation (5%)	1	Job	$ 93,650.00	$ 93,650
Sub-Total				$ **1,021,810**
Contractor Management (2 Construction Seasons)				
Superintendent (8 mon 10hrs/day, 4 mon 8/day)	2,464	Hour	$ 55.00	$ 135,520
Foreman	2,464	Hour	$ 55.00	$ 135,520
Sub-Total				$ **271,040**
Sub-Total Capital Construction				$ **5,275,152**
Allowance for Contractor Change Orders (10%)				$ **527,515**
Contingency (10%)				527,515.20
TOTAL ESTIMATE				$ **6,330,182**

Annual Operation and Maintenance Cost for SP-3b

Transportation to Site for Monitoring	1	Trip	$ 2,100.00	$ 2,000.00
Per Diem and Car Rental Cost for Monitroing	9	man-days	$ 200.00	$ 1,800.00
Heatlh and Safety Monitoring	3	days	$ 150.00	$ 500.00
Monitoring Well Sampling and Analysis	6	sample	$ 150.00	$ 1,000.00
Augur Creek Monitoring (water and sediments)	6	sample	$ 150.00	$ 1,000.00
Sign Replacement	1	LS		$ 1,000.00
Mobilization for O&M of Cover System	Job	Estimate		$ 5,000.00
Fence Repair/Replacement	300	LF	$ 20.00	$ 6,000.00
Vegetation Replacement	1.25	Acres	$ 2,500.00	$ 3,000.00
Top-Soil Cover Repair	500	CY	$ 12.00	$ 6,000.00

Table 11-1
WHITE KING MINE WASTE STOCKPILES Alternative SP- 3b (Revised Weston Estimate)

Description	Quantity	Unit	Unit Rate	Total Cost
Stormwater Management System Maintenacne	Job	Estimate		$ 1,000.00
Former Stockpile Revegetation	1.3	Acres	$ 3,000.00	$ 4,000.00
Semi-Annual Site Inspections	2	Day	$ 1,210.00	$ 2,000.00
Annual Documentation Report	Job	Estimate		$ 5,000.00
Annualized cost for 5-year Review	Job	Estimate		$ 4,000.00
				$ 43,300.00
Contingency (10%)				$ 4,330.00
Annual O&M Cost (with 10% contingency)				**$ 47,630.00**
PRESENT WORTH OF ANNUAL O&M OVER 30 YEAR POST-CLOSURE				**$ 256,691.00**
PW OF INCREMENTAL COST FOR PERPETUAL CARE (a 15% increase)				$ 38,503.00
TOTAL PRESENT WORTH (Capital/Construction/Annualized O&M)				**$ 6,625,376.40**

Notes

Costs are estimates based on setback of Protore Stockpile from Augur Creek and a 24 inch soil cover as calculated by Jacobs Engineering for the U.S. Forest Service. Assumptions are the same as developed in the FS (Appendix I Table 2). O&M is based on FS estimate for Cover Option A (12 inches of soil). Other major assumptions are: Two 5.5 month constructions seasons, cover replacement 5% of total cover annually, and discount rate of 7% and a 30 year operating life.

Table 11-2
LUCKY LASS STOCKPILES
Alternative LL-3

Capital Costs for Lucky Lass Stockpile Alternative LL-3

Description	Quantity	Unit	Unit Rate	Total Cost
Mobilization/Demobilization	Job	Estimate		$ 5,000
Sub-Total				**$ 5,000**
Site Preparation/Improvements				
Temporary Facilities	Job	Estimate		$ 5,000
Haul Roads	Job	Estimate		$ 14,000
Environmental Controls	Job	Estimate		$ 5,000
Sub-Total				**$ 24,000**
Institutional Controls				
Physical Restrictions	1	LS	$ 2,000.00	$ 2,000
Land Use Restrictions	1	Parcel	$ 10,000.00	$ 10,000
Sub-Total				**$ 12,000**
Excavate/Remove Material above PRGs				
Excavate & Place Material at White King mine	3000	CY	6	$ 18,000
Restore Excavations				
Vegetation	2	Acres	$ 2,500.00	$ 5,000
Backfill Excavations	3,000	CY	$ 6.00	$ 18,000
Top Soil	500	CY	$ 10.00	$ 5,000
Riprap Protection along Lucky Lass Discharge	400	CY	$ 14.00	$ 6,000
Sub-Total				**$ 52,000.00**
Reclaim Stockpiles				
Regrade East and West Stockpile	10,000	CY	$ 3.00	$ 30,000
Topsoil	3,500	CY	$ 10.00	$ 35,000
Vegetation	8	Acres	$ 2,500.00	$ 20,000.00
Sub-Total				**$ 85,000**
CONSTRUCTION COST SUBTOTAL				**$ 178,000.00**
Engineering Design	Job	Estimate	10000	$ 25,000.00
Contractor Procurement	Job	Estimate	5000	5000
Local Requirements	Job	Estimate	5000	5000
Construction Management (one season)				
Resident Engineer	240	hour	$ 80.00	$ 19,000.00
Surveying	Job	Estimate	$ 2,500.00	$ 2,500.00
Health and Safety Monitoring	Job	Estimate	$ 1,000.00	$ 1,000.00
Post-Construction Documentation and Certificatio	Job	Estimate	$ 1,000.00	$ 1,000.00
Home Office Allowance (10%)	Job	Estimate	$ 2,350.00	$ 26,000.00
Contractor Management (Superintendent)	240	hour	$ 80.00	$ 19,000.00
SUBTOTAL (Capital and Construction)				**$ 258,000.00**

Table 11-2
LUCKY LASS STOCKPILES
Alternative LL-3

Description	Quantity	Unit	Unit Rate	Total Cost
ALLOWANCE FOR CONTRACTOR CHANGE ORDERS (10%)				**$ 26,000.00**
Contingency (25%)				**$ 65,000.00**
TOTAL ESTIMATE (CAPITAL/CONSTRUCTION) with Contingency				**$349,000**

<u>Annual Operation and Maintenance Cost for WKPW-3</u>

Description	Quantity	Unit	Unit Rate	Total Cost
Mobilization for O&M of Cover System	Job	Estimate		$ 2,000.00
Sign Replacement	1	LS	$ 500.00	$ 500.00
Semi-Annual Site Inspections	2	Day	$ 1,210.00	$ 2,000.00
Vegetation Replacement	0.5	acres	$ 2,500.00	$ 1,000.00
Top-Soil Cover Repair	200	CY	$ 12.00	$ 2,000.00
Annual Documentation Report	Job	Estimate		$ 2,000.00
Annualize cost for 5-year review	Job	Estimate		$ 2,000.00
Sub-Total				**$ 12,000.00**
CONTINGENCY (25%)				**$ 3,000.00**
Annual O&M Cost (with 25% contingency)				**$ 15,000.00**
PRESENT WORTH OF ANNUAL O&M OVER 30 YEAR POST-CLOSURE				**$ 186,000.00**
TOTAL PRESENT WORTH (Capital/Construction/Annualized O&M)				**$ 535,000.00**

Notes: O&M Assumes a discount rate of 7% and a 30 year operating life.

Table 11-3
White King Pond Water Alternative WKPW-3

Captial Costs for WKPW-3

Description	Quantity	Unit	Unit Rate	Total Cost
Mobilization/Demobilization	Job	Estimate		$ 5,000
Sub-Total				**$ 5,000**
Institutional Controls				
Land Use Restrictions	1	Parcel	$ 10,000.00	$ 10,000
Monitoring Well Installation	80	LF	$ 90.00	$ 7,200
Sub-Total				**$ 17,200**
CONSTRUCTION COST SUBTOTAL				**$ 22,200**
Engineering Design	Job	Estimate	$ 3,000.00	$ 3,000
Contractor Procurement	Job	Estimate	$ 1,000.00	$ 1,000
Local Requirements	Job	Estimate	$ 10,000.00	$ 1,000
Contruction Management				
Resident Engineer	60	Hour	$ 80.00	$ 5,000
Surveying	Job	Estimate		$ 2,500
Health and Safety Monitoring	Job	Estimate		$ 2,500
Post-Consturinton Documentation and Certification	Job	Estimate		$ 2,000
Home Office Allowance	Job	Estimate		$ 1,200
Sub-Total				**$ 13,200**
Contractor Management				
Superintendent	60	hour	$ 55.00	$ 3,300
SUBTOTAL (Captial and Construction)				$ 4,000
ALLOWANCE FOR CONTRACTOR CHANGE ORDERS (10%)				
Allowance for Contractor Change Orders (10%)				
Contingency (25%)				
TOTAL ESTIMATE (CAPITAL/CONSTRUCTION) with Contingency				**$ 58,000.00**

Annual Operation and Maintenance Cost for WKPW-3

Description	Quantity	Unit	Unit Rate	Total Cost
Managemtn of Pond Water	Job	Estimate	$ 30,000.00	$ 30,000.00
Transportation to Site for Monitoring	1	Trip	$ 2,100.00	$ 2,000.00
Per Diem and Car Rental Cost for Monitroing	9	Man-Days	$ 200.00	$ 1,800.00
Heatlh and Safety Monitoring	3	Days	$ 150.00	$ 500.00
Monitoring of Pond Water	3	Sample	$ 80.00	$ 200.00
Monitoring Well Sampling and Analysis	6	Sample	$ 150.00	$ 1,000.00
Semi-Annual Site Inspections	2	Days	$ 1,210.00	$ 2,000.00
Annual Documentation Report	Job	Estimate	$ 2,000.00	$ 2,000.00
Annuualize cost for 5-year review	Job	Estimate	$ 4,000.00	$ 4,000.00
Sub-Total				$ 43,500.00
CONTINGENCY (25%)				**$ 11,000.00**
Annual O&M Cost (with 25% contingency)				**$ 54,500.00**
PRESENT WORTH OF ANNUAL O&M OVER 30 YEAR POST-CLOSURE				**$ 682,000.00**
TOTAL PRESENT WORTH (Capital/Construction/Annualized O&M)				**$ 740,000.00**

APPENDIX C

RESPONSIVENESS SUMMARY FOR THE RECORD OF DECISION

WHITE KING/LUCKY LASS SITE

APPENDIX C

PART 3: RESPONSIVENESS SUMMARY

WHITE KING/LUCKY LASS

SUPERFUND SITE

The responsiveness summary addresses public comments on the proposed plan for the White King/Lucky Lass site. The proposed plan was issued on September 29, 1999. The public comment period was held from October 1, 1999 to January 10, 2000, including a two 30-day extension. A public meeting was held in Lakeview, Oregon on October 14, 1999 to present the proposed plan and to accept oral and written public comments. Additional information on the community involvement for this site is discussed in Section 3 of the ROD.

OVERVIEW

The U.S. Environmental Protection Agency (EPA) distributed a Proposed Plan for remedial action at the White King/Lucky Lass site near Lakeview, Oregon. The Proposed Plan identified the preferred remedial alternative for the site. The major components of the proposed remedial alternative for White King/Lucky Lass presented in the Proposed Plan were as follows:

- Containment and Consolidation of the Overburden Stockpile with the Protore Stockpile with a 24 inch cap (12 inches of soil and 12 inches of rock)
- Continued neutralization/monitoring of the White King Pond
- Removal of Soils at the Lucky Lass site which exceed remediation levels and consolidation with the White King stockpiles
- Long term maintenance, monitoring, and institutional controls

EPA received oral comments on the Proposed Plan during the October 14, 1999, public meeting in Lakeview, and seven letters during the public comment period from October 1, 1999, through January 10, 2000. EPA also received 59 pages of comments from Kerr McGee and 151 pages of attachments on the Proposed Plan. Due to the limited number of oral and written comments from community members these comments are presented individually followed by EPA's response. The comments received from Kerr McGee are paraphrased and organized into categories based on the comment.

SUMMARIZED COMMUNITY COMMENTS

Verbal Comments During the Public Meeting

Comment: *A person familiar with the operation of the mine stated that the contractors working on the open pit had no knowledge of the level of radioactivity in each truck load and randomly disposed of materials using both stockpiles. Given the mix of materials in the stockpiles how will they be monitored?*

Response: The remedial action will consolidate the overburden and protore stockpiles into a single mine waste repository with a two-foot thick soil cover. There will be no attempt to

separate higher level radioactivity from lower levels within the stockpile materials. Monitoring will be conducted of ground water, sediment, and surface water to ensure that contaminants are not migrating into Augur Creek. Air monitoring will also be conducted during the remedial action to ensure there are no impacts to air or workers. Long-term inspection and maintenance of the repository will be conducted to ensure that it remains protective.

Comment: *How will equipment decontamination be handled during this project?*

Response: The Remedial Design will include plans for decontaminating equipment and preventing the spread of contamination off the site. The contaminants at the site can be easily removed from vehicles and equipment using conventional washing techniques.

Comment: *Who has been conducting the monitoring of the White King Pond and the addition of limestone?*

Response: This work has been conducted by the Kerr McGee Corporation, with oversight by EPA, ODEQ, USFS, and OOE.

Comment: *Has an area been identified that would provide cover soil or rock for the project?*

Response: No. The remedial design will identify the criteria for this material and potential sources in the area.

Comment: *The levels of arsenic in the Goose Lake valley are higher than at the mine sites, particularly at Hunters Lodge and nearby residences. What is either EPA or DEQ doing to address this "hazard"?*

Response: Drinking water in this area would only be tested and regulated if it serves through a "public water system". Public water systems are those that serve more than 10 individuals. These are regulated by the Oregon Health Division under the Federal Safe Drinking Water Act and Oregon's Administrative Rules Section 333-61. For example, the City of Lakeview's water is required to be tested with results being submitted and available at the Health Division. More information about these systems and any test results could be obtained from the Drinking Water Section of the Oregon Health Division at (503) 731-4010 or http://www.ohd.hr.state.or.us/dwp/docs.

Owners of private domestic wells are only required to sample for coliform bacteria and nitrates as part of a real estate transaction in accordance OAR 333-061-0305 to 333-061-0335. EPA and DEQ encourage all individual well users to have their wells tested and to respond to test results appropriately to protect themselves from naturally occurring contaminants found in the area such

as arsenic and radionuclides. It is the homeowners responsibility for the testing as the state or EPA is not able to fund statewide private well sampling.
The Hot Springs at Hunter's Lodge would be considered a recreational area. The standards for waters that are used for swimming and recreation are also regulated by the Oregon Health Division. The Environmental Services Section of the Health Division can be contacted at (503) 731-4012 regarding any health concerns or testing of surface waters used for recreation. Recreational uses are not the jurisdiction of DEQ or EPA.

Comment: *There are elevated levels of uranium throughout the area of the site and it seems that putting a fence around the stockpiles would be adequate to address any "potential" risks.*

Response: Alternative SP-2 provides a fence (or barrier) to prevent access by medium-to-large mammals, domestic cattle, and humans; however, it does not provide protection for small mammals or prevent erosion and the protectiveness depends on the effectiveness of physical and land-use restrictions. It also would not comply with State of Oregon requirements prohibiting disposal of radioactive material in a floodplain of a river or creek.

Comment: *What happens when wildlife or livestock ingest the water in the pond?*

Response: Historically the White King Pond water has had a pH around 4-5. Except for effects on some aquatic life EPA is not aware of any particular toxic effects on livestock or wildlife from consumption of acidic water. EPA's main concern at this time is with contaminants in the pond sediments and whether they are toxic or can lead to bioaccumulation in aquatic organisms. The ROD requires further evaluation of the sediments to assess the toxicity and bioaccumulation potential of contaminants in order to evaluate the risks and feasibility of environmental protection for the proposed beneficial uses (primarily aquatic habitat). In the short-term livestock watering and recreational use will be restricted by fences while the neutralization efforts and sediment evaluation are being conducted and evaluated.

Comment: *Will the government conduct monitoring of the site in the future?*

Response: Yes. While a contractor will likely conduct the inspection, maintenance, and monitoring required at the site both the state and federal agencies will conduct oversight of these activities for an indefinite period of time. In addition since contaminated materials will remain on site EPA will be required to conduct a detailed review of the effectiveness of the remedy within five years of implementation of the remedy.

Comment: *Either consolidation of the stockpiles or leaving them in place seem like reasonable alternatives. Relocation of the material to another location seems like an unnecessary expense.*

Response: Comment noted. The selected remedy does not relocate the material to another location off-site but does move the material in order to meet State of Oregon requirements for disposal of radioactive material.

Comment: *The level of radiation currently at the site is no greater than what can be found in other areas near the site like in Thomas Creek.*

Response: EPA acknowledges there are probably other areas of radiological mineralization in the area. Those areas that have not been disturbed will not be cleaned up. Generally, the intent is to return the White King Lucky Lass Mines site to either acceptable risk or background levels. Under premining conditions, radiological materials were in the bedrock beneath layers of soil and subsoil. These materials have now been exposed at the surface and need to be consolidated and covered so that they cannot be dispersed above grade by man, animals, or natural erosive processes.

Comment: *The level of radiation at the mine site is lower now, due to the extraction of the uranium, than when it was mined and the levels of radiation are no different from what can be found naturally in other areas near the site. The site has been in its current condition for 35 years with no apparent harmful effects. Why take action at all?*

Response: The levels of radiation in stockpiles and surface soils are not at background. Background is based on levels that are found naturally in the vicinity of the Mines Site which have not been disturbed by mining activity. As stated in the previous response contaminated soils have been exposed at the surface where there was previously soil and subsoil cover. Radium-226 and arsenic in these soils and stockpiles exceed background soil concentrations. The selected remedy is based on the remedial actions that are necessary to prevent exposure and unacceptable risk.

Comment: *How is consideration of current and future costs factored into the proposed project?*

Response: Current costs are based on the capital costs of remediation. Future costs are based on the cost of long-term inspection and maintenance. These are projected for thirty years at a 7% discount rate using the present worth financial model. According to present worth, a sum of money is held in escrow, and future costs are defrayed by compounding interest on the sum.

Comment: *How will the meadow be restored when the stockpiles are moved?*

Response: The selected remedy (SP-3b) will move the overburden stockpile to be co-located with the protore pile in a single mine waste repository. The meadow will be restored in accordance with Oregon mined land reclamation requirements. Revegetation of all disturbed areas will be done so it is comparable in stability and utility to adjacent areas. The dominant herbaceous community within the undisturbed wetlands consists of a combination of hairgrass-sedge moist meadows, sedge-wet meadows, and low sagebrush/bluegrass meadows.

Comment: *The White King stockpile Alternative 3 is acceptable and would seem to cause little* *disturbance.*

Response: The EPA, Federal and State Agencies have reached the same conclusion. Alternative SP-3b provides the greatest measure of long-term effectiveness because of reduced maintenance due to a thicker effective cover and it meets the State of Oregon requirements for disposal of radioactive material.

Comment: *Kerr McGee has a great deal of knowledge and experience with this site and other mines. It is hoped that the agencies listen and give consideration to their suggestions.*

Response: The Agencies appreciate input from community members and agree that Kerr McGee has specific knowledge and experience related to this site. EPA's responses to Kerr McGee's comments are found later in this document.

Comment: *There has been a great deal of discussion about the floodplain of Augur Creek. True flooding occurs at lower elevations in a watershed and not at higher elevations such as at this site. If damage from erosion was going to occur at the site it would have been seen by now. Over the years there has been little movement of the stockpiles.*

Response: White it is true that Augur Creek does not have the erosive potential of larger streams at lower elevations there is evidence of erosion on the stockpiles which is likely the result of wind and water erosion. The extent of this erosion due to the influence of Augur creek cannot be determined. This is particularly evident at the Overburden stockpile where Augur Creek runs parallel to the stockpile.

<u>Written Comments</u>

Comment: *How will the water levels in the White Kings' pond be maintained to keep a consistent pH?*

Response: The water level in the White King pond fluctuates very little throughout the year. The primary factor in controlling the pH will the availability of material to buffer the acidity. Periodic addition of acid neutralizing material such as limestone rock should maintain a neutral pH in the White King pond. Monitoring of the pH will occur to determine the effectiveness of the neutralization efforts in order to make adjustments in the type and quantity of neutralizing agent to be added to the pond.

Comment: *How frequently will the White King pond, Augur creek, and the site soils be tested?*

Response: Ground water, surface water, and sediment monitoring and evaluation will be conducted as part of the remedy. The monitoring frequency will be determined during the remedial design but will occur at a minimum of once per year. Since the levels of contamination in the site soils are not expected to change over time no further soil sampling is planned once the remedial action is complete.

Comment: *It will take more than barbed wire fencing to keep the public off the site.*

Response: EPA agrees that fencing alone will not provide adequate protection from contaminated soils and therefore the remedy includes a soil cover over the mine waste repository.

Comment: *What kind of protection will be provided to workers during and after the cleanup?*

Response: The Remedial Design will include development of a site-specific health and safety plan. This plan will identify potential risks and actions necessary to protect workers during the site cleanup and long term inspection and maintenance program. Typical protection measures may include dust control measures, personal protection clothing and equipment (such as safety glasses, ear plugs, respirators etc.) and monitoring of worker exposures. Oregon OSHA regulations also provide for protection measures for worker safety.

Comment: *Who will be in charge of the project EPA, the Forest Service, or both?*

Response: While EPA had the lead for development of the Record of Decision both EPA and the Forest Service share a responsibility for overseeing the implementation of the remedy. In addition the Oregon Office of Energy and Oregon Department of Environmental Quality are support agencies and will also be involved in overseeing the remedial design, remedial action, and long-term inspection and maintenance program.

Comment: *The sensible solution is to post the mines to trespass and inform the public that the mines are not as hazardous as they have been led to believe.*

Response: Institutional controls or physical access restrictions alone will not provide adequate protection to the public over the long term nor will it meet the Oregon rules for the disposal of radioactive material. Additional actions are required to reduce the risks and prevent erosion and impacts to surface and ground water.

Comment: *Alternative 3 seems to be an acceptable option as it does not require moving soil or disturbing too much other ground at the site.*

Response: Comment noted.

Comment: *Oregon DEQ supports Alternative SP-3b for the White King Stockpiles and considers this alternative to be the most feasible remedial action under application of Oregon environmental cleanup rules and statute. The alternative needs to continue to address important elements of Oregon's Cleanup statues and rules including protection of the beneficial uses of groundwater and surface water and meeting DEQ acceptable risks levels. The ROD should state the cover design expectations and/or set forth specific minimum design standards beyond those* *presented in the Proposed Plan. The design process should consider long term erosion, permanence, operation and maintenance, and the site setting to arrive at the final cover design. The ROD should also include additional specificity, beyond that presented in the Proposed Plan, with respect to institutional controls.*

Response: The ROD includes additional details on the conceptual design for Alternative SP-3b including cover thickness, slopes, use of drainage swales etc. The ROD also includes additional information on institutional controls consistent with the ODEQ institutional control guidance and current land ownership.

Written Comments from Kerr McGee Corporation

The Kerr McGee Corporation (KMC) submitted extensive written comments dated January 7, 2000 on the Proposed Plan, including 59 pages of comments and 151 pages of attachments. Kerr McGee's comments were divided into general headings for the White King and Lucky Lass portions of the site depending on the nature of the comment. EPA's response is organized according to these headings rather than restating the entire comment. Where a heading does not fully reflect all the specific comments under the heading EPA has paraphrased the additional comments in order to represent the comment and provide a complete response.

In general Kerr McGee's comments raise a number of valid points with respect to the technical similarities between Alternative SP-3a and SP-3b. In fact the comparative analysis of alternatives in the FS indicated that they were relatively equal for many of the criteria. In the Proposed Plan EPA identified several potential differences which are worth noting. However, these potential differences were not the primary basis for selection of the preferred alternative. As required by the NCP an alternative must first meet the threshold criterion, protection of human health and the environment and compliance with ARARs, before consideration of the other balancing criteria. It is the State's position that Alternative SP-3a would not meet state laws for disposal of radioactive material. This fact was the primary basis for selection of Alternative SP-3b over Alternative SP-3a.

I. Alternative SP-3a should be chosen as the remedy for the White King portion of the Site.

Comment: *Alternative SP-3a is the best choice because it is completely effective compared to other alternatives and at the least cost.*

Response: In order for EPA to select a remedy for a site under CERCLA it must be both protective of human health and the environment and meet all applicable and relevant or appropriate requirements (ARARs). In some cases, an ARAR may be waived if the statutory standard is met, however at this site EPA has determined that there is no basis for an ARAR waiver. EPA disagrees that Alternative SP-3a is the best choice because it would not meet all ARARS. The Oregon Office of Energy has determined that Alternative SP-3a would not comply with state law under ORS 469.375 and OAR---. The overburden pile under Alternative SP-3a is in the floodplain of Augur Creek and the ARAR prohibits it remaining in the floodplain.

Comment: *State Energy Rules Should Not Affect Selection of Alternative SP-3a. The Rules are legally invalid and do not affect the remedy selection process at this Site.*

Response: EPA has determined that the State of Oregon Energy Rules are an ARAR for this Site. EPA submitted comments during the public comment period of the State's rulemaking process to amend its regulations addressing overburden. EPA requested that the State not adopt the proposed amendments, noting, among other things, that the regulatory amendments regarding flood plain prohibitions appeared to go beyond the statutory provisions. The State proceeded with its rulemaking process, however, and when the rules were finalized, KMC filed a petition with the Oregon Supreme Court challenging the validity of the rules. Many of the arguments included in KMC's comments are similar to those included in its legal briefs filed with the Oregon Supreme Court. The were upheld by the Oregon Supreme Court in January 2001. (Fremont Lumber Co. v. Energy Facility Siting Council, SC No. S46401 (January 11, 2001).

Comment: *The Federal Agencies Have Formally Reached the Conclusion that the Rules Are Invalid and Cannot be Used As ARARs at this Site.*

Response: See response to previous comment. The Federal Agencies have not formally reached a conclusion that the State's rules are invalid and cannot be used as ARARs. Although the Federal Agencies' comments disagreed with the State's position during the State's rulemaking process, the Federal Agencies did not challenge the rules after they were finalized. Although KMC challenged the rules in a petition to the Oregon Supreme Court, the rules were upheld.

Comment: *Even if the rules are finally accredited as ARARs, technical data support the selection of Alternative SP-3a. Alternative SP-3a would satisfy the criteria of the Rules.*

Response: The State of Oregon regulations for disposal of radioactive material prohibit disposal in the floodplain of a creek. The Remedial Investigation Report provides evidence that the overburden stockpile is located within the current and historical floodplain of Augur Creek, and therefore Alternative SP-3a, which would cap the stockpiles in their current locations, would not meet these rules.

The rules include a pathway exemption set forth in OAR 345-050-0035, which exempts certain material from the rules. In order for Alternative SP-3a to comply with the rules, it would have to meet one of the exemptions. The Oregon Office of Energy (OOE), the agency charged with administering these laws, determined that the floodplain and erosion standards apply to the overburden piles and that an exemption is not warranted because the gamma pathway set forth in OAR 3450-50-0035 is exceeded. OOE made this determination based on radium-226 concentrations from vertical borings through the piles. (Please refer to OOE's June 21, 2000 letter which sets forth the reports of sampling data.) OOE compared these concentrations to levels seen at other sites they manage, and concluded that gamma radiation at the White King overburden and protore stockpiles soil samples would result in exposures exceeding 500 millirem per year. OOE has determined that concentrations of radioactive material in the overburden and protore stockpiles at the White King/Lucky Lass Site exceed the pathway exemption and therefore are subject to the requirements of the rule.

KMC claims that the stockpile sampling data shows the bottom half of the overburden stockpile to be exempt from the rules. Based upon the available stockpile data the agencies believe that there is no clear trend in the measured values that lends any confidence toward predicting what the radium levels are in materials even relatively close to the sampled locations. The levels of radium decline and increase in seemingly random ways throughout the stockpile. This is consistent with the random nature by which soils were deposited in the stockpiles (see comment made during the proposed plan public meeting). Based on the above, it is EPA's position that there is insufficient technical data[1] to support an exemption from the rules which would be necessary for the selection of Alternative SP-3a.

Comment: *The Overburden Pile Data Support Selection of Alternative SP-3a. KMC requests that the Federal Agencies review the technical data and determine that Alternative SP-3a would meet all requirements of the Rules, should they be accredited as ARARs, and can withstand erosive forces due to flooding. In addition, when the overburden stockpile is protected with an appropriate cover, the potential for exposure is dramatically reduced and clearly excluded from the Rules.*

Response: See response to previous comment. The Agencies believe that there is insufficient data to support an exemption from the rules. As for the erosion issue given the scale of Augur Creek and of the waste piles, EPA agrees with KMC's comment that the active force of Augur Creek is insufficient to cause any large scale disturbance to the pile.

As for the issue of using an appropriate cover for the stockpiles, the State's evaluation under its rules does not consider the use of a cover or any remedial action designed to reduce radiation levels. OAR 345-050-0035 lists the conditions under which waste materials subject to the rule are to be evaluated. This rule states in relevant part:

...The Council or the Office shall base its finding on an evaluation of potential radiation exposures and effluent releases performed under the following conditions:
(1) The evaluation considers material in the form in which it exists when it is removed from the users' equipment, systems, or settling ponds prior to any dilution or remedial action designed to reduce radiation levels.

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[1] The scope of the data collection during the RI was to determine the nature and extent of contamination in the stockpiles and not necessarily to determine if soils qualified for the pathway exemption which would likely require a much more comprehensive sampling effort.

(2) The evaluation does not consider any ameliorating effects of land use restrictions, maintenance operations, or cover material at the disposal site.

The evaluation as to whether or not the rule applies at the Site must be done as if there were no cover for the piles.

Comment: *Risk Characterization and Land Use Assumptions Should Reflect Likely Risks To*

Support Remedy Selection. Alternative SP-3a would remediate all likely human exposure risks. To the extent that Alternative SP-3b is proposed on the basis of residential exposures, that proposal should be withdrawn because there is no support for that risk management decision.

Response: EPA agrees that both Alternative SP-3a and SP-3b can be equally protective of human health based on the exposure scenarios presented in the risk assessment. However, Alternative SP-3b was not proposed on the basis of residential exposures or human health risks. The risk assessment is included in the Administrative Record for the Site.

Comment: *Alternative PRGs Based on Background Levels for the White King Area Should Be Selected. Kerr McGee requests that the Federal Agencies recognize these naturally occurring background levels and derive PRGs based on these levels. All relevant analysis of the remedy in the Proposed Plan should be adjusted accordingly.*

Response: Cleanup levels in the ROD were selected based on either background, applicable standards, or risk levels, whichever were higher. The statistical basis for EPA's background is documented in Jacob's Engineering *Independent Evaluation Report* dated April 10, 1988. In that report, soil locations were included in the background data set if they were not likely to be influenced by erosion or leaching of constituents from the overburden and protore piles, regardless if they were in a mineralized zone.

The record on the disagreement between Kerr McGee and the agencies on the determination of background is reflected in the agencies comments on this subject during the Feasibility Study. These are included in the Administrative Record. EPA disagrees that the highest levels of arsenic at 1570 mg/kg or Ra-226 levels at 10.3pCi/g be used as background since these values are based on inclusion of samples which could be elevated due to their proximity to the stockpiles. EPA would like to emphasize that the cleanup approach will be guided by visual criteria to determine what is mining related waste followed by confirmational sampling and placement of a clean soil cover. The specific clean up approach is described in the ROD and will be refined during the Remedial Design and Remedial Action Workplan.

Comment: *The Cover Options with Alternative SP-3a are Equally Effective as SP-3b at Controlling Infiltration, Leaching, Percolation, and freeze thaw protection.*

Response: Alternative SP-3a has a greater surface area than SP-3b and we believe that infiltration would increase with surface area. However, EPA agrees that it may be difficult to distinguish infiltration rates, leaching, and percolation between the two alternatives using the same cover, particularly at ground water monitoring wells. We also agree that freeze thaw protection would be roughly equally between the two alternatives using the same cover.- Alternative SP-3b was not proposed on the basis of being more protective of ground water quality than Alternative SP-3a using the same covers. EPA believes that Alternative SP-3b is slightly more effective and permanent considering issues other than those listed in KMC's comments. By consolidating the piles, less surface area is subject to the overall effects of erosion. It will also provide an opportunity to compact the material and place it into a more

stable configuration. It will also place the waste in a single location providing for somewhat easier maintenance and monitoring. The Help modeling analysis cited is useful for design considerations and to develop a more permanent and robust cover but does not in itself support the argument that SP-3a and SP-3b are equally effective overall.

Once a decision was made to select Alternative SP-3b over Alternative SP-3a, based on the ARARs analysis, EPA selected a cover design which represented the best balance of a number of factors including the NCP balancing criteria. In this analysis the need to establish vegetation and minimize biointrusion were two important factors considered by EPA. Infiltration and percolation were not significant factors for this evaluation.

Comment: *Alternatives SP-3a and SP-3b Do Not Differ As to Effects of Erosion*

Response: EPA agrees that engineering design features and the comprehensive operation and maintenance plan components of the selected remedy will go a long way toward reducing erosion of the covered stockpile. Such components were also included with Alternative SP-3a. However, the addition of overburden pile material to the protore pile under Alternative SP-3b can allow more flexibility in incorporating design features to minimize erosion. Such features could include lower cover gradients, placement of lower concentration/activity materials on the top and sides of pile as sacrificial material, and compaction of relocated overburden materials to promote cohesion and armoring.

In addition, the consolidation of soils under alternative SP-3b results in less total surface area subject to erosion as compared to SP-3a. A single stockpile will be somewhat easier to inspect and maintain than two separate stockpiles. Moving the overburden pile will provide for a more geotechnically stable configuration that can be designed to blend into the adjacent terrain. The current location of the overburden pile under Alternative SP-3a is subject to erosion from Augur Creek as well as drainage originating from the White King pond.

Comment: Alternative SP-3a Would Be Reliable and Effective Considering Issues of Biointrusion. A mesh chain link fence under Alternative SP-3a is equally effective as a field fence under Alternative SP-3b in limiting access of herbivores. Whether Alternative SP-3a or SP-3b is selected, the cover should include an additional 6 inch rather than a 12 inch rock layer to control burrowing animals.

Response: The Agencies do not believe a thin cover and a chain link fence is appropriate to control biointrusion. Without continuous maintenance, Alternative SP-3A has no long-term effectiveness against biointrusion into the contaminated soils by climax plant species or burrowing animals. Furthermore, the ability to construct and maintain a chain link fence in an extreme environment as at the Mines site is questionable. It also has an undesirable visual impact. As for the cover, the selected remedy is different from the preferred remedy identified in the Proposed Plan in that an additional 12 inches of soil will be included with the cap as opposed to an additional 12 inches of rock layer. (See Section 14 of the ROD.) While a 24 inch soil cover alone would not eliminate biointrusion entirely, it would be somewhat more effective than the 12 inch soil cover under Alternative SP-3a in reducing biointrusion into the underlying stockpile material for those burrowing animals present in the vicinity of the Site. However, a 24 inch soil cover in combination with the recompacted "clay-like" layer under Alternative SP-3b, with placement of lower activity/concentration material on the top and sides of the piles, would be effective in limiting biointrusion into the underlying contaminated stockpile material.

Comment: *Alternative SP-3a Does Not Differ From SP-3b With Respect to Maintenance. The need for maintenance is not a function merely of surface area. The level of maintenance required is not a function of thickness of the cover. A better indication is to evaluate the respective costs of maintenance. The portions of the cover that are most prone to gully propagation and therefore require the greatest amount of maintenance are those areas with the steepest slopes.*

Response: As with the other issues raised in Kerr McGee's comments maintenance costs were not a criteria which led to the selection of Alternative SP-3b over SP-3a. Alternative SP-3b has less overall surface area and intuitively maintenance costs should be somewhat less all other factors being equal. This seems to be supported in the FS Volume V Table 2-4 where Annual Cover O&M for Alternative SP-3a is higher than Alternative SP-3b regardless of the cover type. We agree that these differences become less with consideration of the higher capital costs of Alternative SP-3b and the long term costs for perpetual care. Despite the estimated similarities in maintenance costs between the two alternatives EPA believes that Alternative SP-3b can be constructed in such a way to minimize those factors, such as slopes , which may lead to higher maintenance costs. These factors will be considered and maximized during the remedial design.

Comment: *There Is No Unacceptable Risk From Radon Emanation. The Proposed Plan appears to favor Alternative SP-3b over SP-3a because SP-3b would purportedly offer greater protection against risks attributable to radon exposure in soils.*

Response: While radon reduction is a potential benefit of a thicker cap it is not the risk driver nor the basis for selection of alternative SP-3b in the ROD. The selection of a cap design is also not based on potential risk from radon emanation. However, radon flux was not measured during the RI and the Administrative Record documents the Agency's concerns with the lack of this information. Radon emissions should still be a consideration because the material has the potential to exceed established criteria. Compacting and configuring the material in Alternative SP-3b will help reduce the potential to elevate radon.

Comment: *Alternative SP-3b Is not Preferable to SP-3a on the Issue of Wetlands Protection. The value of creating a wetlands does not correspond to the nine NCP criteria. Removal of the pile would not result in the establishment of wetlands acreage in all of the footprint. The Proposed Plan cites Executive Order 11990 as a basis for preferring SP-3B over SP-3A, but it is not a promulgated regulation and therefore not an ARAR.*

Response: The Procedures on Floodplain Management and Wetlands Protection are set forth at 40 CFR Part 6 Appendix A and establish agency policy and guidance for carrying out the provision of Executive Order 11988 "Floodplain Management" and 11990 "Protection of Wetlands." Although these provisions are contained in the Code of Federal Regulations, EPA agrees that they do not meet the definition of an applicable or relevant and appropriate requirement (ARAR) under CERCLA. This citation has been deleted from the ROD. Please note, however, that the deletion of the citation does not effect the analysis of selecting Alternative SP-3B over SP-3A given that Alternative SP-3A does not meet the threshold criteria used under CERCLA to select a remedy.

Comment: *Alternative SP-3a is Geomorphically Stable and Would Not be Affected by Flooding Events.*

Response: As stated in a previous response, the RI provides evidence that the overburden stockpile is within the floodplain of Augur Creek and potentially subject to erosion. U.S. Forest Service personnel have also observed this to be the case during the spring.

Flooding potential and velocity calculations were performed for the in-pit disposal option, Alternative 4. However, there is insufficient analysis to determine the geomorphic stability of Alternative SP-3a other than observations associated with unquantified return intervals of flooding events in the Auger Creek Watershed. During flooding of Auger Creek in January 1999, a high water mark was observed on the overburden pile but not on the protore pile.

Under Alternative SP-3a, the location of the overburden pile greatly restricts the Augur Creek floodplain by confining Auger Creek to a small channel. The overburden pile is directly in the path of the original stream channel and is approximately perpendicular to flood flow if the stream jumps its present channel. Geomorphic processes have already eroded the overburden pile and moved overburden material several hundred feet down the valley. No such erosion is evident on the protore pile. In addition, it is important to remember that a significant amount of water is diverted around the high wall and is channeled to the area just below the protore pile. This channel has been observed as flowing at near capacity under peak flow conditions. This channel drains into the meadow and flows toward the overburden pile and combines with the Augur Creek channel. The volume from these drainage areas can add a significant amount of water to Augur Creek and is one of the reasons why erosion has occurred on the overburden pile when none has been observed on the protore pile. The Forest Service has estimated the flows from these drainages increase the Augur Creek flow by as much as 75% at these times. Another contribution to the flows by the overburden pile is the water leaving the pond area. Water flows out of the culvert and behind the overburden pile as well as overland, across the road and then empties into Augur Creek. It is important to note that erosion also occurs on the backside of the overburden pile from water flowing in a man-made channel from the pond. So, there is erosion occurring on two fronts of the overburden pile which would continue under Alternative SP-3a. The same would not be the case for Alternative SP-3b since the consolidated stockpile will be moved out of the floodplain of Augur Creek.

Comment: *Alternative SP-3a Provides Greater Protection Against Short Term Air Quality Impacts. This factor should be added to the evaluation of remedies.*

Response: Short term effectiveness in the context of the nine criteria analysis considers short term risk that may be posed to a community during implementation of an alternative, potential impacts on workers during remedial action and the effectiveness and reliability of protective measures, and potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation. These factors were considered in the comparison of alternatives section of the Feasibility Study and ROD. EPA recognized that Alternative SP-3b involves the excavation and movement of 230,000 cubic yards of material. However, the development and implementation of a site specific health and safety plan and implementation of dust control procedures will ensure adequate protection for workers and impacts to off-site areas during the remedial action. An approved dust control program will minimize off-site impacts. In addition, given the remoteness of the Site, there is little chance for short-term impacts to residences or a potential to impact Lakeview's particulate matter (PM10) levels.

Comment: *Alternative SP-3a Is More Cost Effective Than Alternative SP-3b. Because it also costs less than the others, CERCLA requires that this remedy be selected.*

Response: Alternative SP-3a does not meet the threshold criteria for compliance with ARARS According to the NCP, each alternative must meet the threshold requirements in order to be eligible for selection. Only after it has been determined that ARARS can be met and adequate protection of human health and the environment can be achieved is it appropriate to consider cost effectiveness. Alternative SP-3b meets the threshold requirements and is cost-effective.

II. Lucky Lass - Scope of Reclamation

Comment: *The Proposed Plan should be revised to eliminate the suggestion that a residential risk scenario is likely at Lucky Lass or that it is a basis for remedy selection. In situations where the government has quantified radionuclide levels for risk analysis, the level of radionuclides in Lucky Lass materials is lower than levels EPA has concluded in other contexts as acceptable for unrestricted, residential use.*

Response: The ROD includes the following language: "There is no current residential use at the Site and the likelihood that the area would be used for residential use in the near future is small given the current land ownership and remote location of the Site. However, because of the long-lived radionuclides (decay rate from days to 1000s of years) at the Site, the baseline risk assessment evaluated potential risk under a residential use scenario which includes workers, recreational users (also used to represent potential exposure to a trespasser), and residents." The Oregon Cleanup regulations, which are ARARs for the selection of response actions, require that the excess cancer risk be no greater than 1 x 10^{-6} for each individual carcinogen, and therefore are more stringent than the NCP. These regulations form the basis for the selected remedy at Lucky Lass.

Comment: *By imposing institutional controls for the overburden pile and not indicating to the public that the whole area and offsite pose identical natural risks, the public would be mislead [sic] to believe that the overburden pile presents a unique elevated risk that nearby areas do not.*

Response: The remedial actions described in the ROD addressing the Lucky Lass mine area include removing soils containing arsenic and radium-226 that exceed protective levels for a recreational user and requiring institutional controls to restrict future residential use of the stockpile material and prohibit groundwater use and well drilling within the footprint of the stockpile.

Institutional controls may be used as a component of a remedy to prevent or limit exposure to hazardous substances, pollutants, or contaminants. Institutional controls, however, are not intended to make a statement about on-site versus off-site conditions or risks. EPA doesn't expect that the public will be misled by use of institutional controls as part of the remedy. The public may find information regarding the risks posed by the surrounding area by reviewing documents in the Administrative Record regarding the naturally occurring mineralization that is found throughout the surrounding area of the White King/Lucky Lass Site.

Comment: *CERCLA Does Not Authorize the Government to Require Response Action for Levels of Substances That Do Not Exceed Naturally Occurring Levels. CERCLA has been interpreted and implemented in numerous ways [e.g., Remedial Investigation guidance, NPL delisting decisions, liability determinations, other federal agency practices, CERCLA Section 104(a)(3) and (b)] to show that response actions addressing substances at naturally occurring levels are unwarranted and unauthorized. The Lucky Lass remedy should not be selected* *without consulting the appropriate federal agencies and EPA Headquarters.*

Response: The White King and Lucky Lass Mine Sites will be remediated because of arsenic and radium levels in overburden that exceed acceptable risk levels. Section 104(a)(3) of CERCLA allows response actions in response to a release or threat of release of a naturally occurring substance in an altered form. At White King/Lucky Lass, the stockpiled materials containing radionuclides and arsenic were created solely as a result of mining operations at the Site. Undisturbed soils at the Site were excavated and stockpiled for mining purposes. They are currently present at the Site in an altered form. The conditions at the Site are distinct from the examples posed in the comment. As provided under CERCLA, EPA is not taking response actions at the Site where any naturally occurring substance is located where it is naturally found and in its unaltered form or altered solely through naturally occurring processes or phenomena. With respect to consulting with EPA Headquarters regarding the remedy selected for the White King Lucky Lass Site, EPA has guidance clarifying when a site is appropriate for review by EPA's Remedy Review Board and the Site does not qualify for such review. However, EPA headquarters did review the draft Proposed Plan prior to the public comment period.

III. Other Issues in Proposed Plan and Record

Comment: *The Proposed Plan should be revised in several respects for factual statements of Site history and the PRPs*

Response: The content and amount of detail in the ROD addressing PRPs at the Site is consistent with EPA guidance. Additional issues associated with determining the liability of PRPs is beyond the scope of the Proposed Plan and ROD. Likewise, it is inappropriate for the Response to Comments to go into legal details to respond to the liability arguments against other entities set forth in the KMC's comments.

Comment: *The Proposed Plan and other portions of the administrative record mention previous efforts to study the Site by the USFS. However, those efforts do not meet NCP requirements for data integrity or validity.*

Response: The Draft Environmental Impact Statement (DEIS) was prepared by the Forest Service to comply with the requirements of CERCLA and the National Environmental Policy Act of 1969 prior to EPA listing the site on the NPL. This results of this study were used, as appropriate, to support Site characterization efforts and an overall understanding of the site. All data considered by EPA as a basis for selection of the remedy met NCP requirements for data integrity and validity, where such requirements applied.

Comment: *KMC requests that the White King Mine pH PRG be revised to the pH range from 6.0 to 9. Decreasing the lower limit of the PRG pH range from 6.5 to 6.0 will not adversely affect* *the aquatic environment at White King mine.*

Response: The applicable State surface water standard for the White King pond is found at OAR 340-41-922 and OAR 340-41-925 (d) (B). These standards require the pH to be between 7 and 9. It is currently unclear if this goal is achievable for the White King pond. The monitoring described in the ROD will assess the risks and feasibility of environmental protection for the proposed beneficial uses (aquatic habitat). Once the beneficial use for the White King pond is firmly established and the pond neutralization is implemented EPA will re-evaluate the pH remediation level.

Comment: *The Proposed Plan contains numerous other statements that should be corrected and that should not be used as a basis for choosing Alternative SP-3b. To the extent the proposed remedy is based on these mistakes, the Proposed Plan should be reconsidered in light of the following corrections identified by quoting the Proposed Plan:*

Response: The comment is noted and where appropriate these corrections have been reflected in the ROD. However, such minor revisions do not impact the basis for selection of the remedy. Remediation goals for the pond sediment will be established after a period of monitoring and study as described in the ROD. This action will be documented in an ESD or ROD amendment.

APPENDIX D

FREMONT NATIONAL FOREST

FOREST PLAN AMENDMENT

Appendix D

White King/Lucky Lass Uranium Mines Cleanup Project

Fremont National Forest
Lakeview Ranger District
(Lake County, Oregon)

Forest Plan Amendment # 22

This non-significant, site-specific amendment to the Fremont National Forest Land and Resource Management Plan (Forest Plan) creates a new Management Area 17 – White King/Lucky Lass Uranium Mines CERCLA Remedy.

Emphasis – This MA 17 will emphasize protecting the integrity of the CERCLA Remedy for the White King/Lucky Lass Uranium Mines on the Lakeview Ranger District of the Fremont National Forest. (Section 12 of Final ROD)

Goal – The goal will be to provide institutional controls needed to implement the "Selected Remedy" as discussed in the Record of Decision - White King/Lucky Lass Site. (Section 12 of Final ROD)

Discussion – This MA consists of approximately 240 acres around the White King and Lucky Lass Mines, including the White King pond. Uranium mining activities occurred at the White King and Lucky Lass Mines during the 1950s and 1960s and resulted in current Site conditions, including water-filled excavation pits (ponds) and stockpiled mineralized waste rock/materials. The Site was included on the National Priorities List (NPL) in 1995, and includes both private property and National Forest System land. EPA, with Forest Service concurrence, selected a remedy for the Site pursuant to the Comprehensive Environmental Response, Compensation, and Recovery Act (CERCLA), 42 U.S. Code 9601 et seq. As discussed in the ROD, the remedy will excavate and consolidate the stockpiled material at the White King Mine, including portions of the stockpile at the Lucky Lass Mine. The consolidated stockpile (referred to as the mine waste repository) will be capped with a two-foot soil and vegetative cover and will be located primarily on National Forest System land. The water-filled excavation pit at the White King Mine, which is also partially located on National Forest System land, will be monitored and in-situ neutralization will be continued to maintain a neutral pH level. White King pond sediments will be monitored and further studied. Institutional controls will also be implemented.

Prescriptions –

<u>Mineral Entry</u>.

Area will be withdrawn from mineral entry. The withdrawal includes 240 acres of federal lands specifically described as:

T. 37 S., R 18 E., WM
Section 25: NW ¼ NE ¼
T. 37 S., R 19 E., WM
Section 30: NW ¼ NE ¼, NW ¼ SE ¼, N ½ NW ¼, and SE ¼ NW ¼

Due to the anticipated 100-year plus life-cycle of the mine waste repository, it would be expected that the 20 year mineral segregation established by Public Land Order (#6990) would be further extended for additional 20-year periods.

Prohibitions

- Residential structures or use
- Drinking water well drilling
- Any permanent structures
- Permanent recreation sites (e.g. campgrounds) and uses (e.g. swimming in White King pond)
- Removal of stockpiled material
- Agricultural activities
- Any other use that would impact the integrity of mine waste repository and Lucky Lass stockpile, including grazing on stockpiles and off-road vehicle use

Timber Harvest

There is no scheduled timber harvest on these lands. Harvest activities within this 240 acres only be permitted that protect the CERCLA Remedy.

Fire Suppression Needs

Water from the White King and Lucky Lass ponds may be used for fire suppression needs under the following constraints:

- Use of the White King Pond is preferred over the Lucky Lass Pond
- Water should only be removed from the deepest portions of the ponds
- Care should be taken to avoid disturbing pond sediments when removing water from the pond(s)

Access

Access will be restricted by the presence of a fence or other physical barrier surrounding the White King pond and mine waste repository in order to prevent exposure to and disruption or use of the stockpiled materials and White King pond sediments. As discussed in the ROD, access restrictions at the White King pond may be eliminated in the future depending on success of neutralization and actions to address the risks associated with the pond sediments while access restrictions at the Lucky Lass stockpile will be short-term only lasting until completion of the remedial action. The fence should have gates that can be locked at all times. Warning signs will be posted every 200 feet along the fence/barrier stating the hazards, who to contact, and advising people not to remove or disturb any of the stockpiled material.

Adjacent Property Owners

The adjacent property owners will be contacted annually to discuss the land use restrictions and potential future uses or property transactions that could affect this management area.

Determination that the Forest Plan Amendment is Not Significant Under National Forest Management Act (NFMA)

I have determined that this is not a significant Forest Plan amendment under the NFMA implementing regulations [36 CFR 219.10(f)]. The following factors from Forest Service Handbook (FSH) 1909.12 were considered in this determination

Timing - *Identify when the change is to take place. Determine whether the change is necessary during or after the plan period (the first decade) or whether the change is to take place after the next scheduled revision of the forest plan. In most cases, the later the change, the less likely it is to be significant for the current forest plan. If the change is to take place outside the plan period, forest plan amendment is not required.*

This amendment is to be implemented immediately and will be necessary for the life of the remedy --- 100 plus years. This duration is needed to provide the institutional controls to implement the "selected remedy".

Location and Size - *Determine the location and size of the area involved in the change. Define the relationship of the affected area to the overall planning area. In most cases, the smaller the area affected, the less likely the change is to be a significant change in the forest plan.*

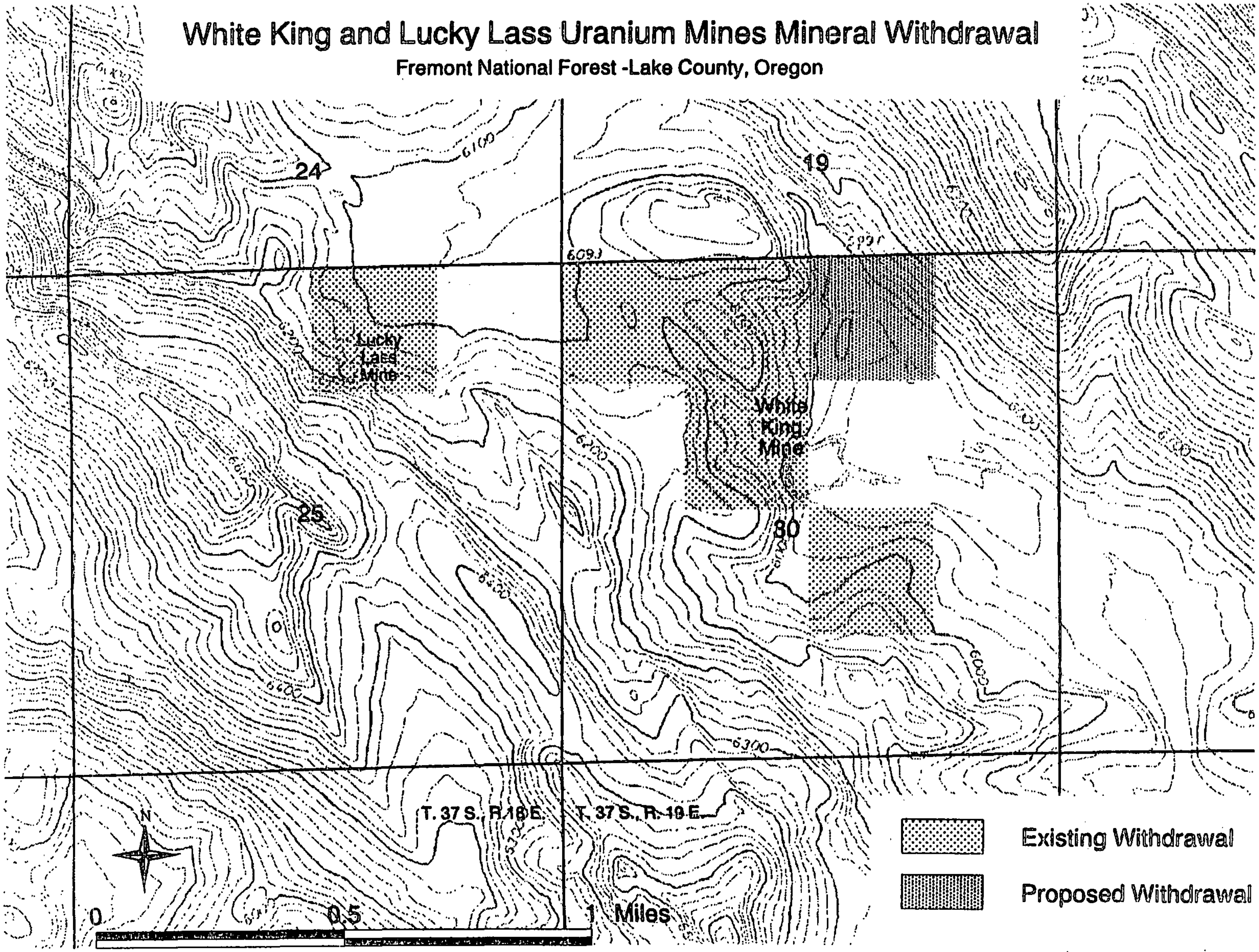
This amendment only affects 240 acres out of the total forest acreage 1,198,301 acres. This is only approximately 0.02 per cent of the Fremont National Forest. (See attached Map from the Environmental Assessment for the Addition to the White King and Lucky Lass Uranium Mines Mineral Withdrawal, dated March 2001).

Goals, Objectives, and Outputs - *Determine whether the change alters long-term relationships between the levels of goods and services projected by the forest plan. Consider whether an increase in one type of output would trigger an increase or decrease in another. Determine whether there is a demand for goods or services not discussed in the forest plan. In most cases, changes in outputs are not likely to be a significant change in the forest plan unless the change would forego the opportunity to achieve an output in later years.*

Because the project specific area is small (240 acres) relative to the total forest acres, the long-term relationships between the levels of goods and services will not be changed.

Management Prescription - *Determine whether the change in a management prescription is only for a specific situation or whether it would apply to future decisions throughout the planning area. Determine whether or not the change alters the desired future condition of the land and resources or the anticipated goods and services to be produced.*

The management prescription is only for the 240 acres. These prescriptions applied to this localized area will not affect anticipated forest wide goods and services to be produced.



White King and Lucky Lass Uranium Mines Mineral Withdrawal

Fremont National Forest -Lake County, Oregon

APPENDIX E

CONCURRENCE LETTERS

WHITE KING/LUCKY LASS RECORD OF DECISION

United States Department of Agriculture
Forest Service
Pacific Northwest Region
P.O. Box 3623
Portland, OR 97208-3623
333 S.W. First Street
Portland, OR 97204

File Code: 2810

Date: September 28, 2001

Mr. Charles E. Findley
Acting Regional Administrator
U.S. Environmental Protection Agency
Region 10
1200 6th Avenue
Seattle, WA 98101

Re: White King/Lucky Lass Mine Site

Dear Mr. Findley:

The United States Department of Agriculture Forest Service (Forest Service) concurs with the remedy selected in the September 2001 Record of Decision (ROD) for the White King/Lucky Lass Superfund Site. A component of the ROD made effective by my concurrence is Fremont National Forest Plan Amendment #22, a copy of which is enclosed. The purpose of the Forest Plan Amendment is to protect the integrity of the remedy selected by the ROD.

The Forest Service is pleased with the selection of a remedy that will protect human health and the environment. We look forward to a continued cooperative and productive relationship with the EPA and the state agencies during remedy implementation.

Sincerely,

Harv Forsgren

HARV FORSGREN
Regional Forester

Enclosure

Oregon
John A. Kitzhaber, M.D., Governor

Department of Environmental Quality
Eastern Region
700 SE Emigrant
Suite 330
Pendleton, OR 97801
(541) 276-4063 Voice/TTY
FAX (541) 278-0168

September 26, 2001

RECEIVED
SEP 28 2001
Environmental Cleanup Office

Mike Gearheard
Director of The Office of Environmental Cleanup
U.S. Environmental Protection Agency, ECL-117
1200 Sixth Avenue
Seattle, Washington 98101

Re: White King/Lucky Lass Uranium Mines Site
Record of Decision

Dear Mr. Gearheard:

The Oregon Department of Environmental Quality (DEQ) has reviewed the draft Record of Decision, for the above referenced project. I am pleased to advise you that DEQ concurs with the selected remedy recommended by EPA. I find that this alternative is protective, and to the maximum extent practicable balances the feasibility factors. Accordingly, it satisfies the requirements of ORS 465.315 and OAR 340-122-040 and 090.

It is understood that the White King Pond will be further evaluated under this Record of Decision. Additional decisions and requirements for the White King Pond may result from this effort particularly with respect to protecting beneficial uses and with respect to potential sediment exposures. DEQ is looking forward to working with EPA during design and implementation to resolve these issues.

If you have any questions concerning this matter, please contact the project manager, Mr. Brian McClure, with the Eastern Region Cleanup Program at (541) 298-7255 ext. 32.

We look forward to the successful implementation of this remedy.

Sincerely,

Barbara W. Sellars
for Joni Hammond
Eastern Region Division Administrator

JBH:BMc
Cc: Terry Hosaka, DEQ
Bill Adams, EPA
Kurt Burkholder, DOJ

September 26, 2001

Mike Gearheard
Director of the Office of Environmental Cleanup
U.S. Environmental Protection Agency, ECL-117
1200 Sixth Avenue
Seattle, Washington 98101

Re: White King/Lucky Lass Uranium Mines Site Record of Decision

Dear Mr. Gearheard:

We have reviewed the draft Record of Decision, for the White King/Lucky Lass Uranium Mines cleanup project. The Oregon Office of Energy concurs with the remedy recommended by EPA. I find this alternative to be protective, as well as practical. I believe it meets the requirements of the applicable disposal standards of the Oregon Energy Facility Siting Council contained in Chapter 345, Division 50.

We understand that the White King Pond will be further evaluated under this Record of Decision. Additional decisions and requirements for the White King Pond may result from this effort particularly with respect to protecting beneficial uses and with respect to potential sediment exposures. OOE is looking forward to working with EPA during design and implementation to resolve these issues.

If you have any questions concerning this matter, please contact me at 503.378.6469. We look forward to working with you and your staff on the final site cleanup.

Sincerely,

David A. Stewart-Smith, Administrator
Energy Resources Division

Cc: Mike Grainey, OOE
Bill Adams, EPA
Kurt Burkholder, DOJ

Golder Associates Inc.

18300 NE Union Hill Road, Suite 200
Redmond, WA USA 98052-3333
Telephone (425) 883-0777
Fax (425) 882-5498
www.golder.com

Golder Associates

REMEDIAL DESIGN WORKPLAN FOR THE WHITE KING / LUCKY LASS MINES SUPERFUND SITE

Submitted to:

U.S. Environmental Protection Agency
Region X
Seattle, Washington

Submitted by:

Kerr-McGee Chemical Worldwide LLC
Western Nuclear Inc.
Fremont Lumber Co.

Prepared by:

Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, Washington 98052

Lee K. Holder, P.E.
Project Manager

Frank S. Shuri, P.G., P.E.
Senior Consultant

April 12, 2004

033-1398.200

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1.0 INTRODUCTION

This document is the Remedial Design Workplan for the White King / Lucky Lass Mines Superfund Site, near Lakeview, Oregon. This Workplan is prepared to describe the approach to be used in conducting remedial design activities by the White King / Lucky Lass Site Group, which consists of Kerr-McGee Chemical Worldwide LLC. (KMCW LLC), Western Nuclear Inc., and Fremont Lumber Company ("Site Group").

1.1 Background

The White King / Lucky Lass Mines Superfund Site (Site) is located in south-central Oregon, approximately 17 miles northwest of Lakeview, Oregon (Figure 1-1). The Site consists of two former uranium mines, located within one mile of each other (Figure 1-2). Portions of the Site are within the Fremont National Forest, managed by the United States Forest Service (USFS), and portions are on private lands owned by Fremont Lumber and the Coppin family trust.

Major features at the White King Mine include the White King Pond (formed when water collected in an open-pit mine), the so-called "protore stockpile", and the "overburden" stockpile. Both stockpiles are actually overburden material. The pit pond occupies approximately 13 acres and contains about 80 million gallons of water. The two stockpiles contain a combined volume of almost one million cubic yards of material.

Augur Creek runs south through the eastern side of the White King Mine area, and receives discharge from the White King Pond.

Major features at the Lucky Lass Mine include the Lucky Lass Pond and the overburden stockpile. This pond covers approximately 5 acres. The Lucky Lass overburden stockpile covers about 14 acres and contains approximately 260,000 cubic yards of material.

1.1.1 Site History

The White King and Lucky Lass uranium deposits were discovered in mid-1955. The local individuals who made the discoveries conducted exploratory work and some mining. Mining began in earnest after Garth and Vance Thornburg leased both mines in September 1955, and then assigned those leases to Lakeview Mining Company (Lakeview Mining) in March 1956.

Lakeview Mining began significant underground ore production in 1958 at the much larger White King Mine. In April 1959, Lakeview Mining converted the White King Mine to open pit mining. This conversion placed the overburden in its present stockpiled location and created the pit that became the White King Pond. Open-pit mining at the White King Mine continued until December 1959. Open-pit mining commenced at the Lucky Lass Mine in 1956.

Lakeview Mining discontinued commercial operations at both mines by early 1960. After 1961, sporadic small-scale mining conducted by others continued at both mines through 1964. Exploration activities at the site occurred through the early 1980s.

The Site was listed on the National Priorities list on April 25, 1995 as a Federal Facility. At the time of listing, the United States Environmental Protection Agency (EPA) stated, "The AEC oversaw mining operations." Remedial investigation and feasibility study (RI/FS) activities were conducted at the Site by Kerr-McGee Corp. from the summer of 1995 through 1999.

Kerr-McGee Corporation conducted a Remedial Investigation (RI) and Feasibility Study (FS) under Superfund procedures and guidelines pursuant to an Administrative Order on Consent. The RI Report was finalized in 1997 (Weston, 1997) and the FS Report was finalized in 1999 (Weston, 1999a). Additional site reports are listed in the FS. The EPA issued a Record of Decision (ROD) on September 30, 2001.

1.1.2 Prior Site Reports

A *Draft Environmental Impact Statement Remedial Investigation/Feasibility Study for the Cleanup and Rehabilitation of the White King and Lucky Lass Uranium Mines* (DEIS) was prepared by/for the United States Forest Service (USFS) in August 1991, and a revised DEIS was issued in 1994. Upon review of the 1994 DEIS-RI/FS Report, EPA determined that further investigation and analysis of remedial alternatives was needed to support a remedial action decision under CERCLA. Kerr-McGee Corporation conducted an RI and a FS under Superfund procedures and guidelines pursuant to an Administrative Order on Consent. The RI Report was finalized in 1997 (Weston, 1997) and the FS Report was finalized in 1999 (Weston, 1999a). Additional site reports are listed in the FS.

1.2 Purpose and Scope

The purpose of this Workplan is to describe the process for engineering design associated with the remediation of the White King / Lucky Lass Mines Superfund Site. Specifically, this Workplan will describe administrative aspects of the design process, identify data needed to complete the design and the approach for obtaining these data, and discuss the deliverables that will be produced during the design process.

This Workplan is primarily oriented toward the earthwork activities at various locations around the Site as described in the ROD (EPA, 2001).

1.3 Design Objectives

The ROD listed remedial action objectives (RAO) for both the White King and Luck Lass areas. These RAOs are:

- Reduce exposure to stockpiles and contaminated off pile soil.
- Reduce and eliminate the release of contaminants from soils to groundwater or surface water to protect for beneficial uses.
- Prevent removal or use of overburden soils.
- Prevent direct contact with contaminated soils at Lucky Lass.
- Prevent future use of stockpile soils with contaminant concentrations in excess of protective levels.

To meet those RAOs, the remedial design (RD) objectives for this project are:

- Recontour the White King protore stockpile so that it is no longer within the Auger Creek floodplain. The ROD estimates that this will require moving approximately 138,000 cy of stockpile soil.
- Excavate the White King Mine haul road, a portion of the Lucky Lass stockpile, and certain off-pile areas where there is evidence of mine-related waste above cleanup levels, and place these materials on the recontoured protore stockpile. The areas and quantities to be excavated will be determined by the off-pile survey described in this workplan.

- Excavate the White King overburden stockpile, which consists predominantly of clay-like material, and place it on the recontoured protore stockpile to form a low-permeability layer. The ROD estimates approximately 465,000 cy of will be excavated.
- Place 18 inches of cover soil and 6 inches of topsoil on the consolidated stockpile surface sufficient to support vegetation, and seed the topsoil surface.
- Place 3 inches of topsoil and reseed those areas where soil has been removed.

Other objectives of the design process will be to recommend appropriate institutional and physical access controls for both White King and Lucky Lass to prevent undesirable uses.

1.4 Summary of Existing Data and Conclusions

The primary sources of existing data and conclusions are the RI Report (Weston, 1997) and the FS Report (Weston, 1999a). Selected relevant information is summarized below at a level of detail to place the additional data needs described in Section 3 in context.

1.4.1 Soils

In the ROD, the EPA selected soil cleanup levels for the following indicator constituents of concern (COCs): arsenic (As) and radium-226 (Ra-226). For the White King Mine, these cleanup levels are 442 mg/kg for arsenic and 6.8 pCi/g for Ra-226. For the Lucky Lass Mine, these cleanup levels are 38 mg/kg for arsenic and 3.6 pCi/g for Ra-226. The EPA determined that use of these indicator parameters provides sufficient cleanup of other COCs.

The FS (Weston, 1999a) provided a number of figures summarizing RI sampling results; several of these figures are provided in Appendix A of this workplan. Arsenic concentrations (surface and subsurface) for the Site are shown on FS Figures 1-7 and 1-8. Ra-226 concentrations for the Site are shown on FS Figures 1-9 and 1-10.

Based on RI data, the mine-related waste materials are primarily in the three stockpiles (two at the White King Mine and one at Lucky Lass). Some additional mine-related wastes may be present outside of these stockpiles.

1.4.2 Naturally Occurring Mineralization

A series of letter reports were prepared by Kerr-McGee Corporation and Weston addressing the issue of background levels (natural soil concentrations) at the Site. The Site is located in the Lakeview Uranium District along with numerous other uranium occurrences and prospects (i.e., potential areas where ore could still be found). In many cases, surface expression of uranium mineralization led to the discovery of these occurrences and prospects. As a result of natural soil formation processes, soils in the vicinity of uranium mineralization may contain levels of uranium-series radionuclides and other associated elements reflective of these occurrences and prospects today at locations which have never been affected by placement of overburden or its weathering.

The letter reports prepared by Kerr-McGee and Weston documented the levels of arsenic and Ra-226 in a variety of soil, rock, and sediment samples in the general vicinity of the Mines Site. More specifically, the reports document elevated levels of arsenic and Ra-226 in White King meadow soils that are likely naturally occurring. Arsenic levels up to 1,570 mg/kg and Ra-226 levels up to 9.9 pCi/g have been identified in White King Meadow soils. These values represent the upper end of the range of naturally occurring soil background levels, based upon current information. Therefore, even though the levels identified by Kerr-McGee and Weston were not used by EPA to set cleanup levels within the piles, these data are still relevant for identification of off-pile mine-related waste.

Means of identifying natural mineralization are described in Section 3.

1.4.3 White King Stockpiles

The physical properties of soils in both White King stockpiles were evaluated as part of the FS (Weston, 1999a). Laboratory test results are reported in the *Treatability Study* (Appendix A of the FS), and additional laboratory and field test results for the "overburden" stockpile are presented in the *Material Handling Report* (Appendix B of the FS).

Mineralogical analysis concluded that the materials in both stockpiles are essentially the same, and this conclusion is supported by geotechnical index tests (FS Appendix A, Section 4). On this basis, testing results for the "protore" stockpile are considered applicable to the "overburden" stockpile.

Existing data pertinent to remedial design is discussed in Section 3 and is briefly summarized here. Of particular relevance for remedial design is the permeability of the clay-like materials. Hydraulic conductivity was measured on undisturbed samples from the "protore" and "overburden" stockpiles and from test pads constructed to evaluate soil placement methods. The results are shown on Figure 3-2, plotted against the initial moisture content and density of the test specimens. These results indicate that the stockpile soils can achieve relatively low permeabilities over a wide range of moisture and density conditions.

Natural moisture contents for both stockpiles are also shown on Figure 3-2. Note that these data are plotted along a line corresponding to 75% relative density, solely for convenience to show these data on the same graph. These data indicate that the soil materials in the overburden stockpile in their existing moisture condition should be able to achieve permeabilities on the order of 10^{-7} to 10^{-8} cm/sec when excavated and recompacted on the consolidated stockpile. Furthermore, it can be assumed with a high degree of confidence for design purposes that these permeability values represent the upper limit of the undisturbed, in-place stockpile soils.

As part of the material handling study, an excavation and placement demonstration was performed using scrapers and sheeps-foot compactors. This activity showed that the overburden stockpile soil was workable just as it came from the pile, and could be effectively placed and compacted with standard construction equipment.

1.4.4 Lucky Lass Stockpile

The physical (i.e., geotechnical) properties of the Lucky Lass stockpile have not been investigated. Based on field observations during the June 18, 2003, site visit it is reasonable to assume that they will be generally similar to those of the White King stockpiles. Because all but a small percentage of these soils have COC levels below the selected soil cleanup levels, the volume of soil that is anticipated to require removal from this stockpile is relatively small. Consequently, only a minor characterization of the physical properties of this material is planned.

With respect to COCs, the RI in Section 4.3.3 notes that the Lucky Lass stockpile has "significantly less" concentrations of metals than the White King stockpiles, and concludes that "the Lucky Lass stockpile contains very small amounts of radionuclides and metals." The ROD summarizes these results in Table 5-3, indicating that the highest concentration of arsenic in the stockpile was 11.9 mg/kg measured at the surface, while the average concentration from depths of 2.5 to 10 feet was 3.7 mg/kg. For Ra-226, the highest individual surface measuring was 4.85 pCi/g (see FS Figure 1-10 in Appendix A) and at depth, 8.3 pCi/g (see FS Figure 1-10 in Appendix A). As listed in Table 5-3, Ra-226 had an average activity of 2.0 pCi/g from depths of 2.5 to 10 feet.

2.0 REMEDIAL DESIGN MANAGEMENT

2.1 Project Organization and Key Personnel

The White King / Lucky Lass Site Group has retained Golder Associates Inc. (Golder), the U.S. operating company of Golder Associates, to perform the remedial design and supporting studies for the Site. Golder Associates is an international group of employee-owned, consulting engineering companies specializing in the technical fields of site remediation, environmental engineering, soil and rock engineering, engineering geology, and hydrogeology. Golder Associates is one of the world's leading mining consultants, with extensive experience in mine site remediation. This project will be staffed primarily out of the Golder Redmond, Washington, office. Over 100 technical professionals are resident in this office, supported by full CADD, GIS, and other design support personnel. Additional sediment studies described in the White King Pond and Augur Creek Study Workplan will be supported by specialists from Golder Associate's Calgary and Saskatoon offices.

The key personnel for this project are shown in the project organization chart (Figure 2-1). Resumes of key personnel are provided in Appendix B.

2.2 Remedial Design Deliverables

The remedial design process will involve a number of deliverables. Draft documents will be submitted to EPA, USFS, Oregon Department of Environmental Quality (ODEQ), Oregon Office of Energy (OOE), and (if an appropriate contact is identified by the U.S. government) the U.S. Department of Energy (successor to the Atomic Energy Commission) for review. Once all comments have been received in writing from those agencies that elect to submit comments, the Site Group will provide appropriate responses to the comments. These responses will be discussed with the agencies in a telephone conference or, if deemed necessary, a meeting at the EPA's office in Seattle, Washington. Upon completion of the comment resolution process, the draft documents will be revised incorporating agreed-upon changes. This workplan satisfies the initial tasks EPA has set out in overall work for the Site.

Documents will be submitted at several points during the design process, following the schedule in Section 2.3.. These include the 30% Design, Prefinal Design, and Final Design. Because various documents depend on each other, they will be at differing stages of completion during each phase of the design process. However, by the end of the remedial design process, the following specific deliverables will be prepared:

2.2.1 Field Investigation Report

The Field Investigation Report will describe sampling methods, sample locations, and results of the field investigation activities described in this workplan. An outline of this report is provided in Appendix C.

2.2.2 Design Report

The Design Report will describe the features of the remedial design in detail, and will serve as an umbrella document for the drawings, specifications, and other construction documents. The Design Report will describe each major feature of the remedial activity, and indicate how the design satisfies the requirements of the ROD. Key design calculations will be included as an appendix. An outline of the Design Report is included in Appendix D.

2.2.3 Design Drawings

Construction drawings suitable for bidding will be prepared. Drawings will be D size (34" x 22"), which allows for reduction to half-size at 11" x 17" for review purposes.

A preliminary list of construction drawings is shown in Table 2-1. This list was developed based on project requirements and our experience with work of this type, and includes the critical elements typically required. This list may change as the project evolves.

2.2.4 Technical Specifications

Technical specifications suitable for bidding will be prepared in Construction Specifications Institute (CSI) 3-part format. To the extent practical, these will incorporate existing specifications prepared by Golder, the U.S. Army Corps of Engineers, and other entities. For standard project requirements, particularly Division 1 (Administrative) sections, we will use existing material from the Site Group.

A preliminary list of Technical Specifications is shown in Table 2-2. This list was developed based on project requirements and experience with work of this type, and includes the critical elements that are typically necessary. This list may change as the project evolves.

2.2.5 Draft Construction Quality Assurance Plan

A draft Construction Quality Assurance (CQA) Plan will be prepared. This plan will establish the testing and observation requirements that would be needed during remedial construction. It will also address responsibility and authority, personnel qualifications, documentation, changes and clarifications, and other administrative requirements. An outline of the CQA Plan is presented in Appendix E.

2.2.6 Draft Inspection, Monitoring, and Maintenance Plan

A draft Inspection, Monitoring, and Maintenance (IM&M) Plan will be prepared. This plan will establish inspection procedures for the consolidated stockpile, revegetated areas, diversion ditches, fences, and other permanent project features. Maintenance procedures will be established in general terms for various adverse conditions. The IM&M Plan will also include a Water Quality Monitoring Plan for surface and groundwater and supporting documents such as field sampling and laboratory analysis plans. The IM&M Plan will establish inspection and monitoring frequencies for all activities, and will address reporting requirements.

2.2.7 Capital Construction and IM&M Cost Estimate

A cost estimate for capital construction and IM&M activities will be prepared and submitted as part of the design documents.

2.3 Schedule

The proposed schedule for remedial design work is provided in Figure 2-2.

Table 2-1. Preliminary List of Construction Drawings

Drawing Title	Comments
Cover Sheet	Include project location map
General Notes and Symbols	
Site Features	Include limits of work, stockpile identifications, laydown areas
Survey Control	Show existing monumentation
Existing Topography – Lucky Lass Stockpile	Indicate removal area
Existing Topography – White King Overburden Stockpile	
Existing Topography – Protore Stockpile	
Off-Stockpile Soil Removal Plan	Areas and depths, with control points; include haul road
Final Grades – Lucky Lass Stockpile	
Final Grades - White King Overburden Stockpile Area	
Final Grades – Consolidated Stockpile	
Consolidated Stockpile Sections and Details	
Access Roads – Plan	
Access Roads – Profiles	
Access Roads – Sections and Details	
Erosion Control – Plan	
Erosion Control – Details	
Surface Water Management Plan – Lucky Lass Area	
Surface Water Management Plan – White King Area	
Surface Water Management Details	
Subsurface Interceptor Trench	If required
White King Pond Highwall Seeps	Plan and Details, if required
Restoration Area Plan	Grading / seeding requirements for specific areas, may require several sheets, may include topsoil borrow area
Fencing Plan	
Fencing Details	

Table 2-2. Preliminary List of Technical Specifications

Section No.	Title	Comments
01010	Summary of Work	Include construction sequence and schedule
01050	Surveying	
01060	Health and Safety	Reference H&S Plans
01100	Environmental Protection	Include permit conditions
01300	Submittals	Include project record requirements, as-builts
01400	Quality	Reference CQA Plan
01510	Temporary Facilities	
02110	Clearing and Grubbing	
02220	Earthworks	Excavation, placement, borrow sources, stockpile management for all soil materials, including overburden, existing stockpile soil, clay cover, clean cover soil, armor rock, ditch lining
02270	Erosion Control	Cross-reference 01100
02505	Access Roads	Include surface course, culverts
02830	Fencing	
02930	Restoration	Regrading, positive drainage, seeding

3.0 DATA NEEDS AND FIELD SAMPLING PLAN

This section identifies the data needed for remedial design, and describes the data quality objectives (DQOs), field procedures and analytical methods that will be used to obtain these data. The Quality Assurance Project Plan (QAPP) is provided as Appendix F.

3.1 Gamma Radiation Correlation to Ra-226 Concentrations

3.1.1 Problem Statement

What are the correlations for differing site areas between Ra-226 concentrations (pCi/g) and gamma radiation detected by the gamma survey instrumentation?

3.1.2 Identification of Decision

In order to perform the gamma radiation survey (Section 3.2), it is first necessary to determine the site-specific correlations for differing site areas between Ra-226 concentrations (pCi/g) and gamma radiation detected by the gamma survey instrumentation (Ludlum Model 2221 or equivalent). The correlation study will allow determination of Ra-226 concentrations from gamma survey data.

Separate correlations will be developed for different areas that will be included in the gamma survey (Section 3.2). These will include:

- White King area soils from near the base of the protore stockpile
- White King area soils from the middle of the meadow (between protore stockpile and the haul road)
- Areas adjacent to Augur Creek between the two White King stockpiles
- Lucky Lass soils from near the base of the Lucky Lass stockpile.

If field observations during the correlation work indicate that other areas have significant potential, in the opinion of the field personnel, to have different gamma correlations from the above areas, then additional correlations may be developed for these areas.

3.1.3 Sampling and Analysis Program

The procedures in this section will be repeated for each correlation to be developed.

The correlation target area will be divided into 10-meter-square subareas. Soil samples will be obtained from 10 of these subareas, selected at random. Approximately equal soil quantities will be obtained from each subarea, such that the total soil volume will fill a container at least 4 ft diameter and 8 inches deep. The soil will be homogenized as it is placed in a container on-site using a portable cement mixer or equivalent. The gamma survey instrument will be placed a fixed distance above the center of the container for a minimum of 10,000 counts, and the measurement recorded.

In addition, a separate container of approximately the same dimensions will be filled with clean sand. This container will be placed in at least three (3) varying locations from the nearest stockpile. For each location, the gamma survey instrument will be placed above the center of the container for a minimum of 10,000 counts, and the measurement recorded.

"The boundary of the Augur Creek correlation area will be 10 meters on either side of the edge of the creek along its length within the White King area (see Figure 3-1).

The boundary between the "near stockpile" and "meadow" correlation areas at White King will be determined in the field using professional judgment based on field observations of the soil materials and on the results of the sand container measurements. The intent will be to divide the areas such that significant radioactive "shine" effects from the piles are restricted (to the extent practical) to the "near stockpile" correlation area. However, the "near-stockpile" area will be at least 10 meters wide along the base of the stockpiles."

Seven (7) samples of the homogenized soil will be obtained for chemical analysis from different locations within the container. The samples will be sent to a qualified commercial laboratory for analysis. The samples will be analyzed by gamma spectroscopy for Ra-226, thorium-232 (Th-232), potassium-40 (K-40), and their degradation products.

Using the calibration procedure in Appendix G, the gamma survey instrument will be calibrated before the survey measurements using 10 pCi/g Ra-226 calibration blocks traceable to the National Institute of Standards and Technology (NIST) and using blank (0 pCi/g) blocks.

During the fieldwork, daily checks will be performed using the check procedures in Appendix G. The daily checks serve to verify that the gamma equipment is performing within acceptable tolerances.

3.1.4 Study Boundaries

Correlations will be developed for site soils within the gamma radiation survey study boundaries (see Section 3.2.4).

3.1.5 Decision Rule

For each correlation to be developed:

1. The average (mean) and standard deviation of the Ra-226 concentrations for the soil samples will be averaged.
2. Outliers will be considered values that differ from the mean value by more than 3 standard deviations.
3. The average and standard deviation will be recalculated without outliers, and outlier rejection repeated until there are no outliers.
4. A linear correlation will be determined using the average Ra-226 concentration of the soil samples (after outlier rejection), the associated field gamma radiation measurements, the calibration block measurements, and (if necessary) the sand/background measurement.

If two correlations appear very similar, then the data will be analyzed using the t-test with the null hypothesis at the 95% confidence interval that the two data sets are statistically not different. If appropriate based on this analysis, a single correlation may be developed to use for both areas.

The minimum detectable activity (minimum detectable Ra-226 concentration) will be determined for each soil area in conformance with NRC Reg. Guide 4.14. The correlation will be considered usable if the minimum detectable Ra-226 concentration is below the applicable cleanup level.

3.1.6 Decision Error Limits

The decision error limits are the statistical criteria in the decision rule.

3.2 Off-Pile Survey

3.2.1 Problem Statement

What "off-pile" areas (areas outside of existing mine waste stockpiles) contain mine-related waste (not natural mineralization) requiring removal to the consolidated stockpile? These materials are present outside of the stockpiles either by placement during mining or by erosion from the stockpiles.

3.2.2 Identification of Decision

The ROD specifies that mine waste materials away from the stockpiles at the White King and Lucky Lass mine sites that exceed cleanup levels are to be removed and placed on the consolidated stockpile. Results of the gamma radiation survey will be used in remedial design to determine extent of off-piles soils to remove to the consolidated stockpile.

3.2.3 Sampling and Analysis Program

The gamma survey instrument will be calibrated before the survey measurements using the calibration procedure in Appendix G. During the fieldwork, daily checks will be performed using the check procedures in Appendix G. The daily checks serve to verify that the gamma equipment is performing within acceptable tolerances.

Survey measurement locations will be determined using global positioning system (GPS) equipment. The GPS calibration and operations procedures in Appendix H will be followed.

The survey will be conducted along approximately parallel lines extending perpendicularly away from the three existing stockpiles. For Augur Creek, survey lines will approximately parallel Augur Creek. The Augur Creek survey area will extend 10 meters from each edge of the creek. Where stockpile survey lines and Augur Creek survey lines intersect, the Augur Creek lines will be followed for the survey. The parallel lines will be approximately one (1) meter apart. The survey personnel will walk with the gamma survey instrument at a speed of 1-2 miles/hour (determined using GPS). The instrumentation will automatically record the location, date, time, and count-rate every 2 seconds.

Each line will be extended until the measurements indicate that the soil consistently meets the cleanup level, based on the applicable correlation developed as described in Section 3.1

3.2.4 Study Boundaries

The survey will begin at the edges of the existing two White King stockpiles and the Lucky Lass stockpile and extend out radially until the data indicate that soils meet the applicable Ra-226 cleanup levels. The survey will also extend 10 meters on either side of Augur Creek in the vicinity of the two existing White King stockpiles. In addition, two clearing areas potentially impacted by mining (shown on Figure 3-1) will be included in the survey. The maximum areal extent expected for the gamma survey is shown on Figure 3-1.

3.2.5 Decision Rule

Off-pile areas with soils above the applicable Ra-226 cleanup levels will be determined based on the gamma radiation survey results. The gamma survey data will be converted to pCi/g for comparison to Ra-226 cleanup levels using the applicable site-specific correlation (see Section 3.1).

Prior to the survey, the survey areas will be subdivided using 10-meter-square grids (100 m^2 subareas) and documented on topographic maps. The survey data will be imported into a graphic information system (GIS). The GIS will then be used to calculate the gamma count averages of the 10-meter-square grids. If the grid average exceeds the applicable cleanup level, then the entire grid area will be considered for removal. In addition, if the average of any 30 adjacent measurements exceeds three (3) times the applicable cleanup level, then the area represented by those measurements will also be considered for removal. "Considered for removal" means that the design will determine the extent of soil to remove within each affected grid area such that, after removal, all of the affected grid areas will meet the cleanup level. For relatively uniform contamination, this means that soil will be removed from the entire grid area. However, if the grid contains a localized "hot spot", then removal of the "hot spot" may be sufficient to achieve the cleanup goal."

It is expected that some natural mineralization will be encountered in the survey areas. Material outside the stockpiles will be considered natural mineralization, and not mine-related waste to be removed, if:

- The material is visually distinct from surrounding soils and extends more than one foot below the ground surface, or
- The material is visually distinct from stockpile soils and is not part of a pattern of elevated radioactivity extending from a stockpile (i.e., the evidence is that the material did not erode from a mining stockpile).

3.2.6 Decision Error Limits

The decision error limits are the statistical criteria in the decision rule.

3.3 Geotechnical Data Collection – General Procedures

Much of the geotechnical data required for design will be obtained by excavating test pits and collecting bulk samples. The general procedures for these activities will be the same regardless of the purpose of the investigation, and are as follows.

Test pits will be excavated to depths up to about 15 feet using a rubber-tired backhoe. Samples will be collected and test pits logged (including photographs) by Golder personnel in accordance with Golder Procedures TP 1.2-21 *Geotechnical Test Pit Logging & Sampling* and TP 1.3-1 *Geologic Mapping of Soils Exposed in Test Pits* (in Appendix I). Number and locations of test pits are described in the following sections. In all cases, if the actual conditions appear to vary significantly, the number of test pits may be increased. Test pits will be located in a uniform distribution throughout the investigation area, subject to local access and other factors. Upon completion, all test pits will be backfilled and then flagged for location with GPS survey equipment. Test pits will also be documented photographically.

Bulk samples for geotechnical testing will be collected in 5-gallon buckets; samples for moisture content testing will be collected in small plastic jars. Samples for chemical analysis will be collected in accordance with Golder Procedures TP 1.2-18 *Sampling Surface Soil for Chemical Analysis* and TP 1.2-23 *Chain of Custody* (in Appendix I). Bulk samples may be collected from soil excavated from test pits or by hand-shovel excavation.

3.4 Volumes for the Consolidated Stockpile

3.4.1 Problem Statement

What are the volumes of material that will be added to the existing protore stockpile to form the consolidated stockpile? This information will be required to prepare grading plans for the consolidated stockpile.

3.4.2 Identification of Decision

The problem will be addressed by estimating the following quantities of soil materials:

- Volume of the White King "overburden" stockpile.
- Volume of the portion of the White King "protore" stockpile to be moved out of the Augur Creek floodplain.
- Volume of the haul road.
- Volume of White King off-pile soils to be moved to the consolidated stockpile.
- Volume of Lucky Lass off-pile soils to be moved to the consolidated stockpile.
- Volume of the Lucky Lass stockpile to be moved to the consolidated stockpile.

3.4.3 Sampling and Analysis Program

This information will be developed based on: (1) volume analyses based on topographic data developed in 2000, and (2) the results of the off-pile survey described in Section 3.2.

3.4.4 Study Boundaries

The features that will be evaluated to calculate the consolidation volumes are identified on Figure 3-1 and Drawing 2 in Appendix J.

3.4.5 Decision Rule

The pre-conceptual design (Appendix J) suggests that the proposed footprint for the consolidated stockpile has a capacity approximately 20% greater than the presently identified requirements. Therefore, if the upper limit of the estimated volumes is within this 20% factor, the capacity of the consolidated stockpile will be considered adequate for the project. The design will indicate that the upper portion of the pile will be developed only as required, and the design will include requirements for grading and drainage to be applied at the final elevation.

3.4.6 Decision Error Limits

Volumes measured from the 2000 topographic data will be calculated using the average end area method with AutoCAD. The uncertainty of these calculations is typically 5% or less.

3.5 Consolidated Stockpile Shear Strength

3.5.1 Problem Statement

What is the shear strength of the combined soils? This information will be required for slope stability analyses during design, to ensure that the proposed side slopes will be stable.

3.5.2 Identification of Decision

If the proposed side slopes on the consolidated stockpile do not exhibit adequate stability, the slopes will be reduced to obtain acceptable stability.

3.5.3 Sampling and Analysis Program

Minimum shear strength parameters will be calculated by back-analysis of existing stockpile slopes, which have been stable for at least 40 years, based on visual observations during the June 18, 2003, site visit.

3.5.4 Study Boundaries

The steepest slopes in the existing protore, overburden, and Lucky Lass stockpiles will be analyzed to estimate minimum shear strength parameters.

3.5.5 Decision Rule

Slope stability will be considered acceptable if a factor of safety of 1.5 or greater is obtained using standard, industry-accepted analysis methods.

3.5.6 Decision Error Limits

The lowest calculated shear strength values will be used in the stability analysis of the consolidated stockpile. The minimum factor of safety of 1.5 reflects industry practice to accommodate uncertainty in material properties and other factors.

3.6 Consolidated Stockpile Compaction Characteristics

3.6.1 Problem Statement

Two closely related questions are:

- What are the compaction characteristics of the combined soils?
- What is the existing moisture content of the combined soils?

This information will be required to prepare the specification for soil placement and to provide data for potential bidders, respectively.

3.6.2 Identification of Decision

Soil permeability is related to the degree of compaction and the moisture content during compaction. There are no explicit permeability requirements in the ROD for soils placed in the consolidated stockpile, only the description that they will form a "low permeability layer" (ROD Section 12.2.1, second bullet, page 12-3). The attenuation modeling described in the *Treatability Study* (TS, Weston, 1999, *Final Feasibility Study, Volume II, Appendix A: Treatability Study – Characterization and Leachability of Stockpiled Materials*), which indicated negligible impacts to downgradient groundwater from stockpile leaching (TS page 1-2), assumed a hydraulic conductivity value of 1 x 10^{-6} cm/sec for stockpiled soils (TS Table 3-9). This value is therefore considered the target hydraulic conductivity for soils placed in the consolidated stockpile.

3.6.3 Relevant Existing Data

Data on the relationship between hydraulic conductivity and compaction, as well as natural moisture content, was obtained for both the *Treatability Study* and the *Material Handling Report* (MHR, Weston, 1999, *Final Feasibility Study, Volume II, Appendix B: Material Handling Report*). These data are summarized in Table 3-1.

The hydraulic conductivity results indicate that the soils from both stockpiles achieved the target permeability over all moisture and density conditions tested. The data also indicate lower permeability values at higher moisture contents, as expected for clayey soils. The natural moisture content data indicates that no moisture conditioning will be required during construction, provided that the construction methods do not cause excessive wetting or drying.

Table 3-1. Existing Hydraulic Conductivity Data

Relative Density[(a)]	Relative Moisture[(b)]	Hydraulic Conductivity (cm/sec)	Reference
Protore Stockpile			
90%	-2%	4 x 10^{-7}	TS Table 4-1
95%	+2%	2 x 10^{-7}	TS Table 4-1
Overburden Stockpile			
90%	-2%	1 x 10^{-6}	TS Table 4-1
95%	+2%	8 x 10^{-7}	TS Table 4-1
Test Pads			
80%	+22%	3 x 10^{-8}	MHR Attachment C Table 1[(c)]
84%	+16%	1 x 10^{-8}	MHR Attachment C Table 1[(c)]
86%	+10%	5 x 10^{-7}	MHR Attachment C Table 1[(c)]

(a) Relative to maximum dry density determined in accordance with ASTM D1557.
(b) Relative to optimum moisture content determined in accordance with ASTM D1557.
(c) Relative density and moisture calculated using compaction curves in MHR Attachment C, Plates 2, 12, and 9, respectively.

Natural moisture contents are summarized in Table 3-2:

Table 3-2. Existing Natural Moisture Content Data

Natural Moisture Content[a]	Reference
Protore Stockpile	
+12%	TS Table 4-1
+12%	MHR Table 3-2
+8%	MHR Table 3-2
+11%	MHR Table 3-2
+5%	MHR Table 3-2
+8%	MHR Table 3-2
+10%	MHR Table 3-2
Overburden Stockpile	
+11%	TS Table 4-1
+14%	MHR Table 3-2
+15%	MHR Table 3-2
+28%	MHR Table 3-2
+19%	MHR Table 3-2
+9%	MHR Table 3-2
+7%	MHR Table 3-2
+17%	MHR Table 3-2
+8%	MHR Table 3-2

(a) Relative to optimum moisture content determined in accordance with ASTM D1557.

The data in Tables 3-1 and 3-2 are plotted on Figure 3-2. These data are plotted along a line corresponding to 75% relative density solely for convenience to show these data on the same graph:

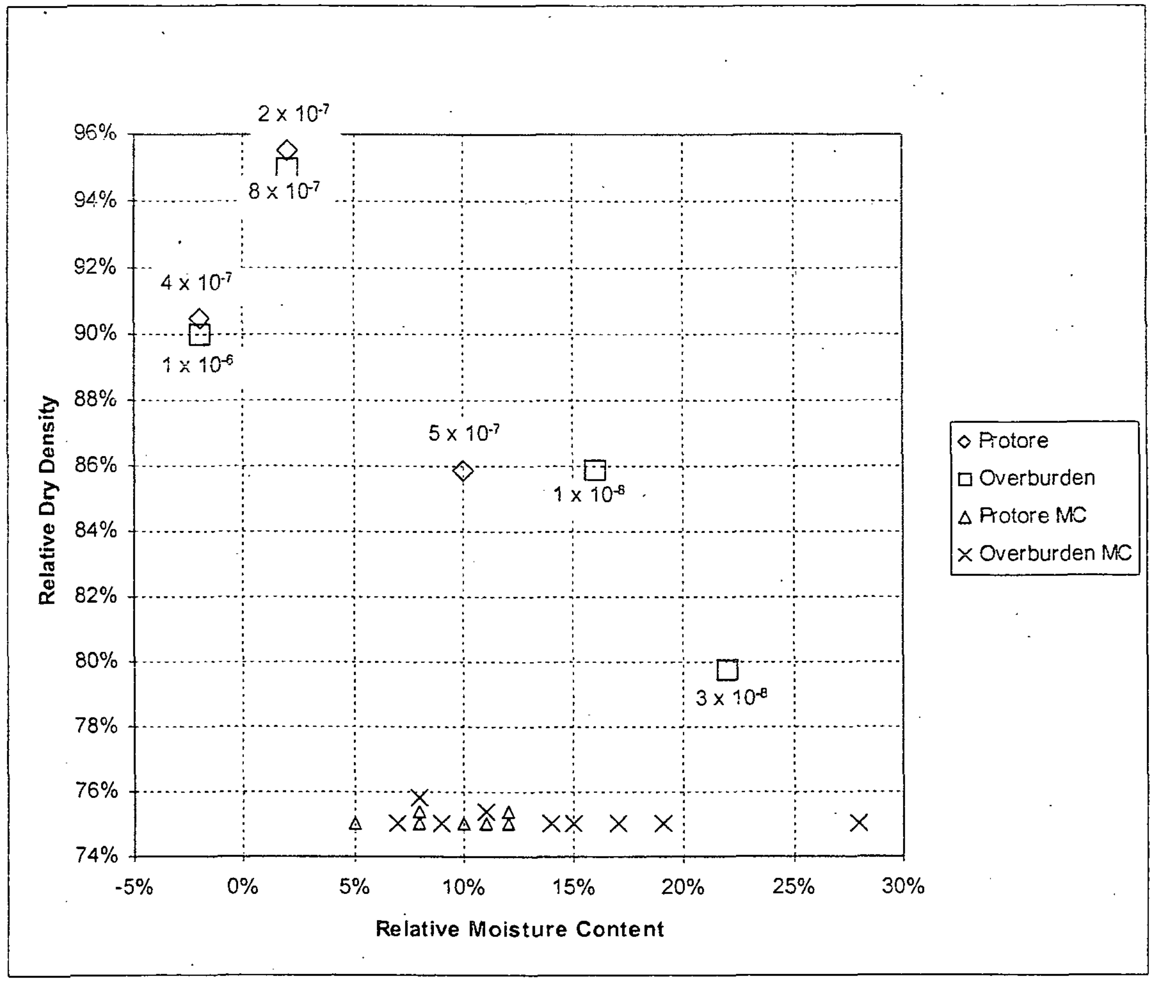


Figure 3-2. Existing Permeability, Compaction, and Moisture Content Data

3.6.4 Sampling and Analysis Program

The Haul Road area requires additional geotechnical characterization for design purposes. Bulk soil samples will be collected from the Haul Road at three locations, near each end and in the center. As part of this process, test pits will be excavated through the Haul Road into the underlying soils to determine the thickness of the Haul Road and the nature of the subgrade soils. Test pits will be terminated when firm native soil or rock is encountered or three feet below the base of the Haul Road, whichever is less.

3.6.5 Study Boundaries

This data need applies to "clay-like" soils that will form the upper portion of the consolidated stockpile. There is a large volume of clay-like material in the protore and overburden stockpiles (557,000 cy; MHR Table 3-1) which has been demonstrated to meet the permeability requirement. This material occurs at the lower elevations of each stockpile (MHR Figures 3-1 through 3-6), and consequently the soil placement sequence will be defined as follows in order to ensure that the clay-like soil is placed in the upper part of the consolidated stockpile:

- First phase of soil placement: off-pile areas, Lucky Lass Stockpile local areas, upper coarser-grained layers of overburden stockpile, and that portion of the protore stockpile to be removed.
- Second phase of soil placement: remaining portion of protore stockpile to be removed and remainder of overburden stockpile.

At the present time, the only soil removal area that is not adequately characterized for design purposes is the Haul Road. The approach for determining the removal sequence for this material is described in the following decision rule.

3.6.6 Decision Rule

Index properties for materials that hydraulic conductivity testing indicated had acceptable permeability are summarized in Table 3.3.

The properties in Table 3-3 typically correlate with permeability. Soils from the Haul Road will be sampled and tested for percent fines (ASTM D1140) and Atterberg limits (ASTM D4318). If the results of these tests fall within the range of data presented in Table 3-3, or exhibit higher plasticity and fines content, the soil may be placed at any location in the consolidated stockpile, and consequently, may be removed at any time during remedial action.

Table 3-3. Geotechnical Index Properties

Percent Fines[a]	Liquid Limit	Plastic Limit	Plasticity Index	Reference
Protore Stockpile				
39	69	21	48	TS Table 4-1
Overburden Stockpile				
39	73	23	50	TS Table 4-1
Test Pads				
77	90	33	57	MHR Table 3-2
58	75	29	46	MHR Table 3-2
52	69	33	36	MHR Table 3-2

(a) Percentage of material by dry weight passing the U.S. #200 sieve.

If the index test results are below the ranges in Table 3-3, the hydraulic conductivity of the soil will be tested to determine if it meets the target permeability (ASTM D5084). If the Haul Road soil meets the target permeability value, it may be placed at any location in the consolidated stockpile. If this soil does not meet the permeability requirement, then the following options are available:

- If the subgrade below the Haul Road is capable of supporting heavy earthmoving equipment such as scrapers, then the Haul Road may be removed as part of the initial soil consolidation described previously.
- If the subgrade is not suitable for heavy traffic (e.g., thick layers of organic material), then the construction contractor may be required to sequence his earthwork operations so as to place the Haul Road soil in the consolidated stockpile beneath soil that meets the target permeability requirement.

In all cases, compaction testing (ASTM D1557) will be performed to provide data for preparing specifications.

3.6.7 Decision Error Limits

Index properties, compaction, and if necessary, permeability, will be measured by a qualified laboratory using ASTM standard methods. This will ensure accuracy within ASTM limits. A minimum of three tests of each type will be performed to account for natural variability; the average of the test results will be used for the analysis, unless the design engineer determines that additional conservatism is necessary.

3.7 Potential Borrow Areas – Topsoil and Cover Soil Volumes and Properties

3.7.1 Problem Statement

What is the available volume of topsoil and/or cover soil in potential borrow areas?

What are the handling characteristics (cohesiveness, weather susceptibility, etc.) of these soils?

3.7.2 Identification of Decision

The decision is whether the potential borrow areas contain the required volume of topsoil and cover soil with appropriate soil properties. If the borrow areas contain more than is needed, then the detailed design will include a development sequence so that disturbed areas and haul distances are minimized. If the borrow areas do not contain sufficient material, additional areas will be identified for investigation.

In addition, any restrictions or conditions required for placement of the borrow soils need to be identified for use in preparing the technical specifications.

3.7.3 Sampling and Analysis Program

Test pits will be excavated at a frequency of about 2 per acre. This will result in a minimum of 8 pits in the Hillside Area and 12 pits in the Clear Cut Area, shown on Drawing 3 in Appendix J. The Lucky Lass Stockpile will also be investigated to allow consideration of using soils from this stockpile for cover soil on the consolidated stockpile. At the Lucky Lass Stockpile, 12 test pits will be excavated and bulk samples collected for testing.

For additional information on potential topsoil, a minimum of 3 test pits will be excavated in Stockpile Area and the Taper Zone Area (see Drawing 3 in Appendix J), for a total of 6 test pits. These pits will be excavated to about 1 foot below the base of the topsoil layer, estimated to be no more than a few feet thick (see MHR Figures 3-1 through 3-6).

The thicknesses of topsoil and cover soil will be measured each of the test pits in the potential borrow areas. The areas for the volume calculations will be determined from existing topographic maps.

Soil testing will include grain size distribution and plasticity. These characteristics will be determined using ASTM test methods D422 and D4318, respectively.

3.7.4 Study Boundaries

The potential topsoil and cover soil borrow areas are shown on Drawing 3 in Appendix J.

3.7.5 Decision Rule

The pre-conceptual design (Appendix J) suggests that the following approximate volumes will be needed:

- Topsoil – 30,000 cy
- Cover soil – 67,000 cy

The borrow sources will be considered adequate if they can provide these volumes. If the potentially available topsoil volume does not appear to be sufficient, part of the topsoil volume may be met by amending cover soil with imported organic material.

Test data will be reviewed for determining if any placement restrictions or conditions are necessary, based on standard earthworks practice.

3.7.6 Decision Error Limits

Soil thickness will be determined from test pits at a limited number of locations. Standard practices will be used to evaluate the variability between test pits. Unless the variability appears to be unusual relative to residual soil deposits of this type, the average of soil thicknesses measured in the test pits will be assumed to adequately represent site conditions.

The geotechnical tests will be performed by a qualified laboratory using ASTM standard methods. This will ensure accuracy within ASTM limits.

3.8 Potential Gravel Borrow Area Volumes and Properties

3.8.1 Problem Statement

What is the available volume of gravel in a potential borrow area?

What is the quality (durability) of the gravel?

Is cover soil also available in the potential borrow area?

3.8.2 Identification of Decision

The decision is whether a potential borrow area contains the required volume of gravel with appropriate properties. Gravel would be obtained by extending a former gravel pit at the north end of the consolidated stockpile. The gravel will be produced from native rock that is highly fractured. Based on visual observations of the former pit wall, the excavated material will have a range of particle sizes. Because specific particle size distributions will be required for various uses of the gravel, it is likely that the excavated material will need to be screened. Information about the particle size distribution will therefore be required to determine the costs for this project element and to estimate the total volume and configuration of the excavation. The required gravel sizes will be determined during the design.

If the excavated material must be screened, the undersize fraction may be suitable as cover soil. This would reduce the area of other borrow sources that must be disturbed. Grain size distribution data will allow an estimate of the volume of this by-product material associated with the required volume of gravel.

Gravel will serve as erosion protection until vegetation becomes sufficiently established. Naturally occurring 3H:1V soil slopes (the maximum proposed design slope) were observed during the June 18, 2003 site visit. These natural slopes were stable, supported stands of natural vegetation comparable to those in flatter areas, and showed no signs of erosion. Hence, the gravel will not need to be a permanent erosion control measure, but will only be relied upon for the first few years after remedial activities have been completed. In this context, the gravel should be sufficiently durable so that it does not degrade significantly over about 20 years.

3.8.3 Sampling and Analysis Program

For evaluating gravel size distribution and obtaining samples for durability testing, three (3) boreholes will be drilled in the Expanded Gravel Borrow Area shown on Drawing 4 in Appendix J. If the actual rock conditions appear to vary significantly, the number of boreholes may be increased.

The boreholes will be located in a uniform distribution throughout the potential borrow area, subject to local access and other factors.

The boreholes will be drilled to approximately 50 ft below the existing ground surface, which will encompass the entire thickness of material planned for excavation. The holes will be diamond cored using wireline equipment and, at a minimum, double-tube core barrels to provide maximum recovery and minimize disturbance. The core will be logged and placed in core boxes by Golder personnel in accordance with Golder Procedure TP 1.2-2 *Geotechnical Rock Core Logging*. Upon completion, all boreholes will be flagged for location with GPS equipment.

The fracture frequency and spacing in rock cores from exploratory boreholes will be the primary source of data on expected size distribution, supplemented by visual observations of the existing face of the former gravel pit.

Gravel durability will be determined by performing the LA Abrasion Test (ASTM C535) and the Sulfate Soundness Test (ASTM C88).

To determine the thickness and obtain samples of potential cover soil, a total of 6 test pits will be excavated in the study area. Soil testing will include grain size distribution using ASTM test method D422.

3.8.4 Study Boundaries

The potential borrow area is shown on Drawing 4 in Appendix J.

3.8.5 Decision Rule

The pre-conceptual design (Appendix J) suggests that approximately 11,000 cy of gravel will be needed.

For the proposed gravel borrow area, if enough suitable material is identified, the decision on its use will involve comparing the costs of excavating and screening at the site to importing gravel from off-site sources.

The gravel will have acceptable durability if the loss during the LA Abrasion Test is less than 50% and the loss during the Sulfate Soundness Test is not more than 20% after 5 cycles.

3.8.6 Decision Error Limits

Gravel data will be obtained from a limited number of boreholes at specific locations. Standard practices of geologic interpretation will be used to evaluate the variability of the rock between boreholes. The geotechnical tests will be performed by a qualified laboratory using ASTM standard methods. This will ensure accuracy within ASTM limits.

3.9 Potential Gravel Borrow Area Excavation Method

3.9.1 Problem Statement

What are potentially suitable excavation methods for gravel?

3.9.2 Identification of Decision

In order to provide the most cost effective construction bids and prepare specifications, it is necessary to know the excavation method for the borrow source. Bedrock that can be ripped with large equipment will have significantly different requirements than rock which requires blasting.

3.9.3 Sampling and Analysis Program

Testing will consist of determining the seismic (p-wave) velocity of the bedrock. Approximately 800 feet of seismic refraction line will be run within the footprint of the Expanded Gravel Borrow Area shown on Drawing 4 in Appendix J. The number, length, and orientation of the lines will depend on initial field results. Geophone spacing will be sufficient to penetrate to a depth of about 50 feet. Field activities will be performed by Golder personnel in accordance with Golder Procedure TP 1.1-14 *Land Seismic Refraction Survey* (in Appendix I). The results of this activity will also be used to correlate geologic conditions between the boreholes.

3.9.4 Study Boundaries

The potential borrow area is shown on Drawing 4 in Appendix J.

3.9.5 Decision Rule

Rippability will be determined by the use of standard tables from earthworks equipment manufacturers, supplemented by geotechnical interpretation. Typically, seismic velocities of 6,000 ft/sec or less indicate rippable material. Velocities greater than 8,000 ft/sec will indicate that blasting is probably required.

3.9.6 Decision Error Limits

The accuracy of seismic velocity measurements depends on a number of site-specific factors and is difficult to quantify. For this study, the results will be evaluated in conjunction with other geologic and geotechnical information to estimate the accuracy. If the seismic velocities are in the intermediate range, the construction specifications will include the option to use either excavation method.

3.10 COCs in Potential Borrow Materials

3.10.1 Problem Statement

Are COCs in the borrow soils (topsoil, cover soil, and gravel) above cleanup levels?

3.10.2 Identification of Decision

Borrow materials should not contain COCs above cleanup levels for the White King stockpiles.

3.10.3 Sampling and Analysis Program

A representative sample will be collected from each of the test pits and boreholes in each of the potential borrow areas.

Chemical screening tests will be performed on cover soil materials for the indicator parameters arsenic and Ra-226. Details of sampling procedures and analytic methods are included in the QAPP (Appendix F).

3.10.4 Study Boundaries

The potential borrow areas are shown on Drawings 3 and 4 in Appendix J.

3.10.5 Decision Rule

Cleanup levels in the ROD are 442 mg/kg for arsenic and 6.8 pCi/g for Ra-226.

3.10.6 Decision Error Limits

Error limits are those associated with the pertinent EPA test procedures listed in the QAPP.

3.11 Bedrock Depth Upslope of Consolidated Stockpile

3.11.1 Problem Statement

What is the depth to competent (unweathered) bedrock immediately upslope of the consolidated stockpile margin? This information is required to design a ditch, trench, or other feature to intercept groundwater flow along the soil-bedrock interface, thereby reducing potential seepage into the consolidated stockpile.

3.11.2 Identification of Decision

The decision is the type of interceptor to be constructed.

3.11.3 Sampling and Analysis Program

The key inputs to the decision that need to be evaluated in the field are the depth to bedrock and the excavation characteristics of the overlying materials.

Test pits will be excavated to refusal to identify the top of bedrock. Test pits will be located at approximately 100-ft intervals along the western margin of the proposed consolidated stockpile. This activity will be performed in conjunction with evaluation of the Hillside Area borrow source; where appropriate, the same test pit will be used for both purposes.

3.11.4 Study Boundaries

The study area will be the hillside immediately upslope of the consolidated stockpile, as shown on Drawing 1 in Appendix J.

3.11.5 Decision Rule

The decision as to the type of interceptor will be made during the remedial design on the basis of technical feasibility, effectiveness, and cost.

3.11.6 Decision Error Limits

Decision error limits are not applicable to this data need.

3.12 Bedrock Permeability

3.12.1 Problem Statement

What is the potential for groundwater seepage into the consolidated stockpile from upslope areas?

3.12.2 Identification of Decision

The decision will be whether or not it is necessary to further consider the effects of groundwater from areas upslope of the consolidated stockpile on COC release.

3.12.3 Sampling and Analysis Program

The key decision inputs will be:

- Depth to bedrock (see Section 3.11)
- Permeability of the bedrock adjacent to the consolidated stockpile.

An estimate of the mass permeability of the basalt bedrock will be required. This parameter will be determined by performing slug tests in existing boreholes upslope of the protore stockpile. This testing will be performed in accordance with Golder Technical Procedure TP 1.2-17 *Rising Head Slug Test* (in Appendix I).

3.12.4 Study Boundaries

The study area will be the hillside immediately upslope of the consolidated stockpile, as shown on Drawing 1 in Appendix J.

3.12.5 Decision Rule

Based on existing data, the in-place permeability of the stockpiled soils can be assumed to be 1×10^{-7} cm/sec or less. If the permeability of the bedrock adjacent to the consolidated stockpile is higher than this value, then groundwater will tend to flow preferentially through the bedrock, and the potential for significant infiltration into the stockpile will be negligible.

3.12.6 Decision Error Limits

Test error limits are discussed in Golder Technical Procedure TP 1.2-17 *Rising Head Slug Test* (in Appendix I).

3.13 White King Pond Highwall Seeps

A seep survey will be performed on the "highwall" of the White King Pond, to document the occurrence and nature of the seeps, in order to determine the need for mitigation. Field measurements will consist of measuring pH with a portable meter, and estimating the flow rate with "stopwatch and bucket" or other simple methods. Photographs of seeps will be taken to document conditions. Flow in adjacent diversion ditches, which might be contributing to seeps, will also be observed. The seep investigation will be performed in early summer, as some seeps have been observed to dry up in later parts of the year. A follow-up survey will be performed in late summer or early fall to identify any seeps that persist throughout the year. Seep locations will be recorded on a topographic map of the site and documented photographically.

4.0 REFERENCES

EPA, 2001. *White King / Lucky Lass Superfund Site Record of Decision*, Office of Environmental Cleanup, EPA Region 10, Seattle, Washington, September 2001.

Weston, Roy F., Inc., 1997. *Final Remedial Investigation Report, White King / Lucky Lass Mines Site, Lakeview, Oregon*, Kerr-McGee Corporation, Oklahoma City, Oklahoma, August 25, 1997.

Weston, Roy F., Inc., 1999a. *Final Feasibility Study, White King / Lucky Lass Mines Site, Lakeview, Oregon*, Kerr-McGee Corporation, Oklahoma City, Oklahoma, August 27, 1999.

Weston, Roy F., Inc., 1999b. *White King Pond Neutralization Report*, Kerr-McGee Corporation, Oklahoma City, Oklahoma.

<u>ASTM Standards:</u>

C88 Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

C535 Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

D422 Standard Test Method for Particle-Size Analysis of Soils

D1140 Standard Test Methods for Amount of Material in Soils Finer Than the No. 200 (75-um) Sieve

D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort

D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

D5084 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

FIGURES

Figures

FIGURES

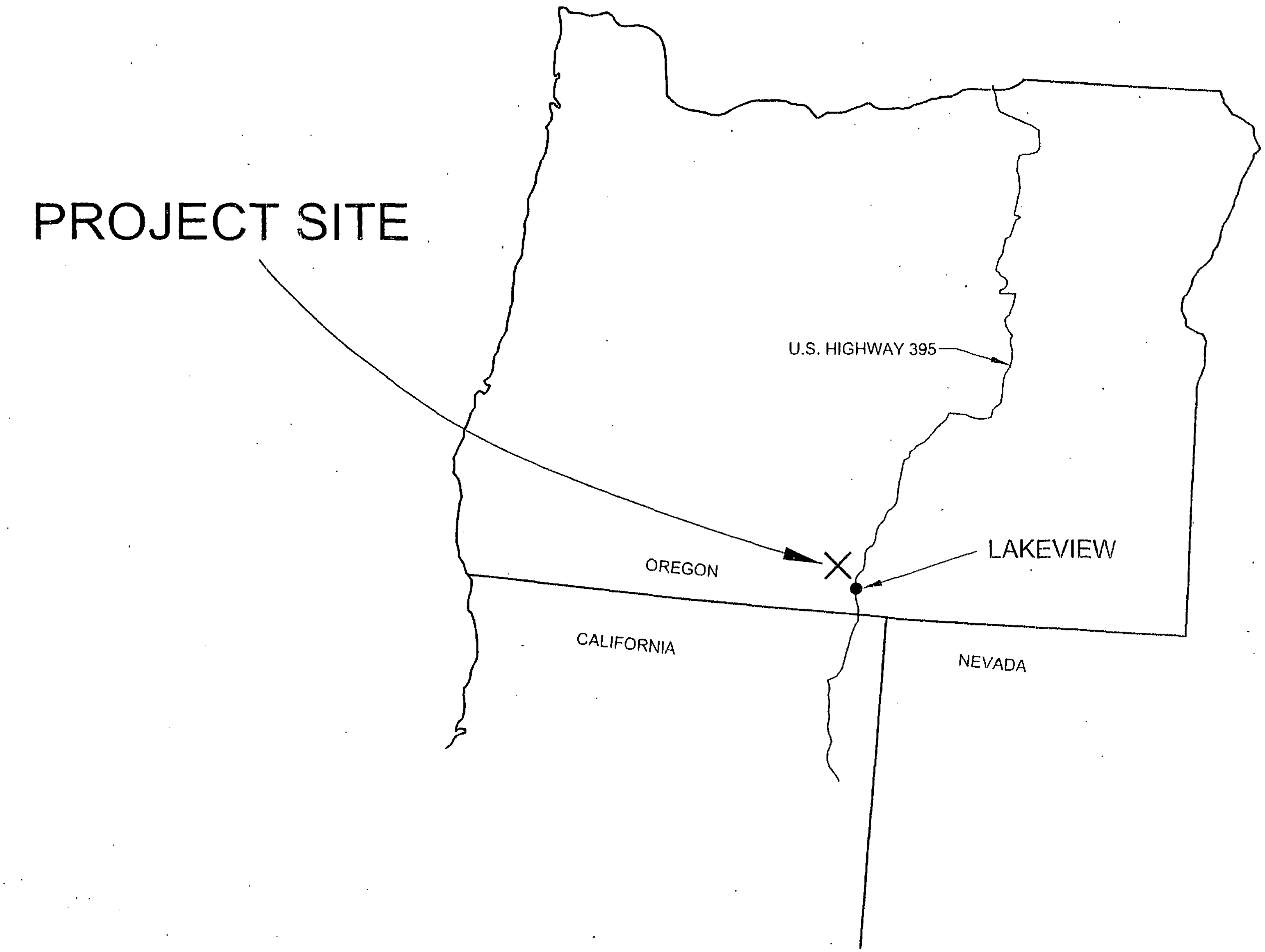


FIGURE 1-1
PROJECT LOCATION
WHITE KING - LUCKY LASS REMEDIATION / OR

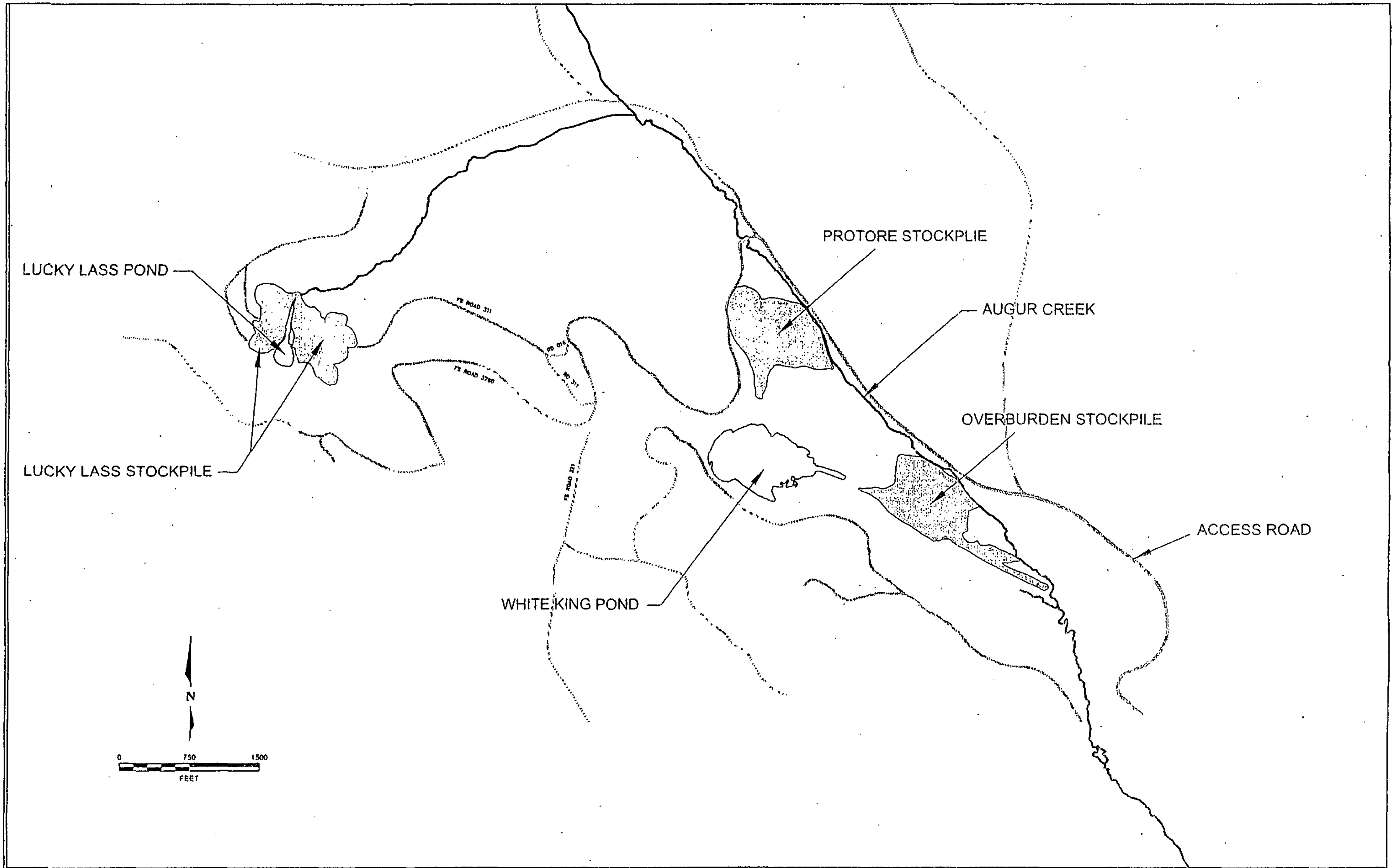


FIGURE 1-2
SITE MAP
WHITE KING - LUCKY LASS REMEDIATION / OR

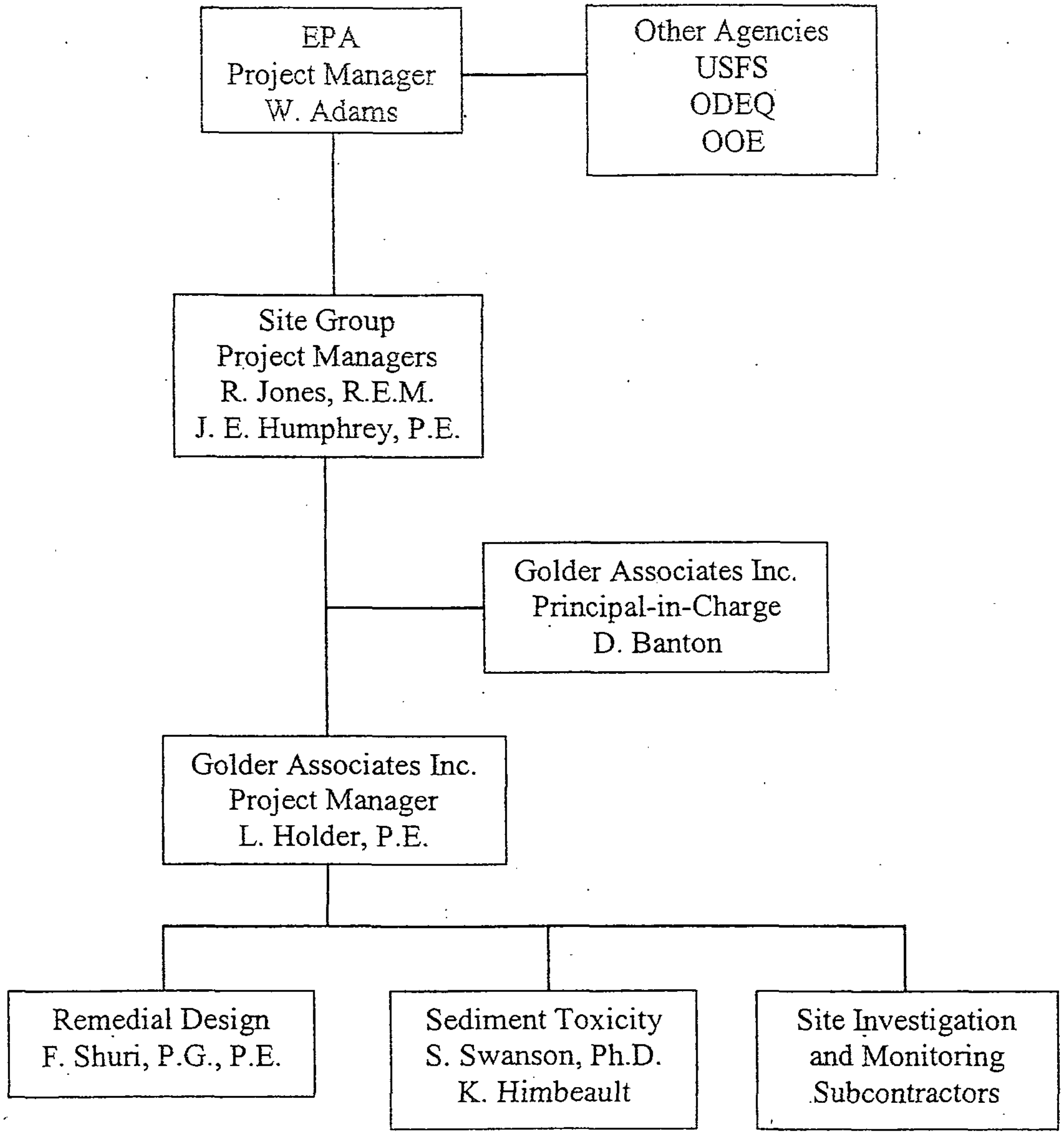


Figure 2-1. Remedial Design Organization Chart

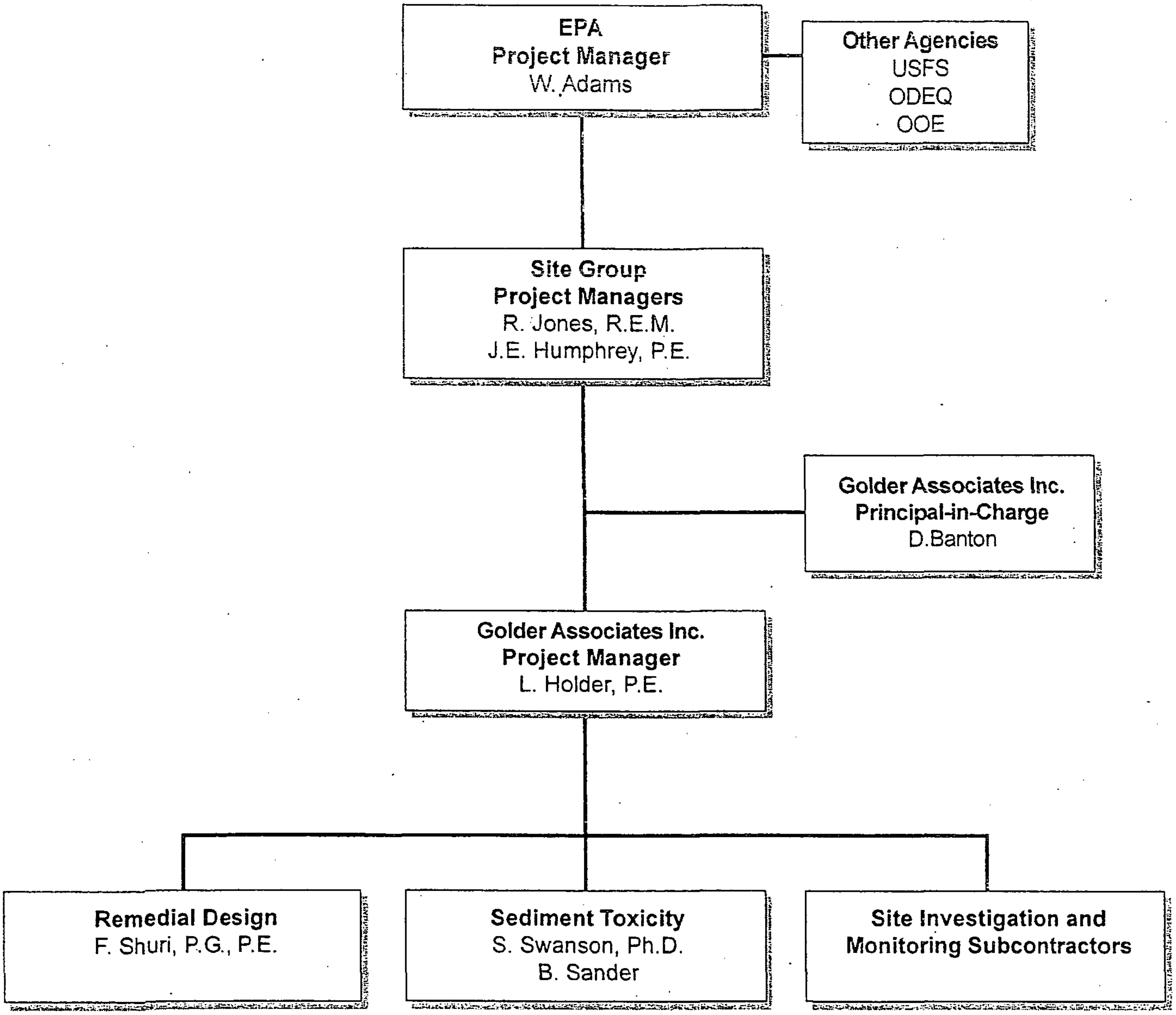


FIGURE **2-1**

REMEDIAL DESIGN ORGANIZATION CHART

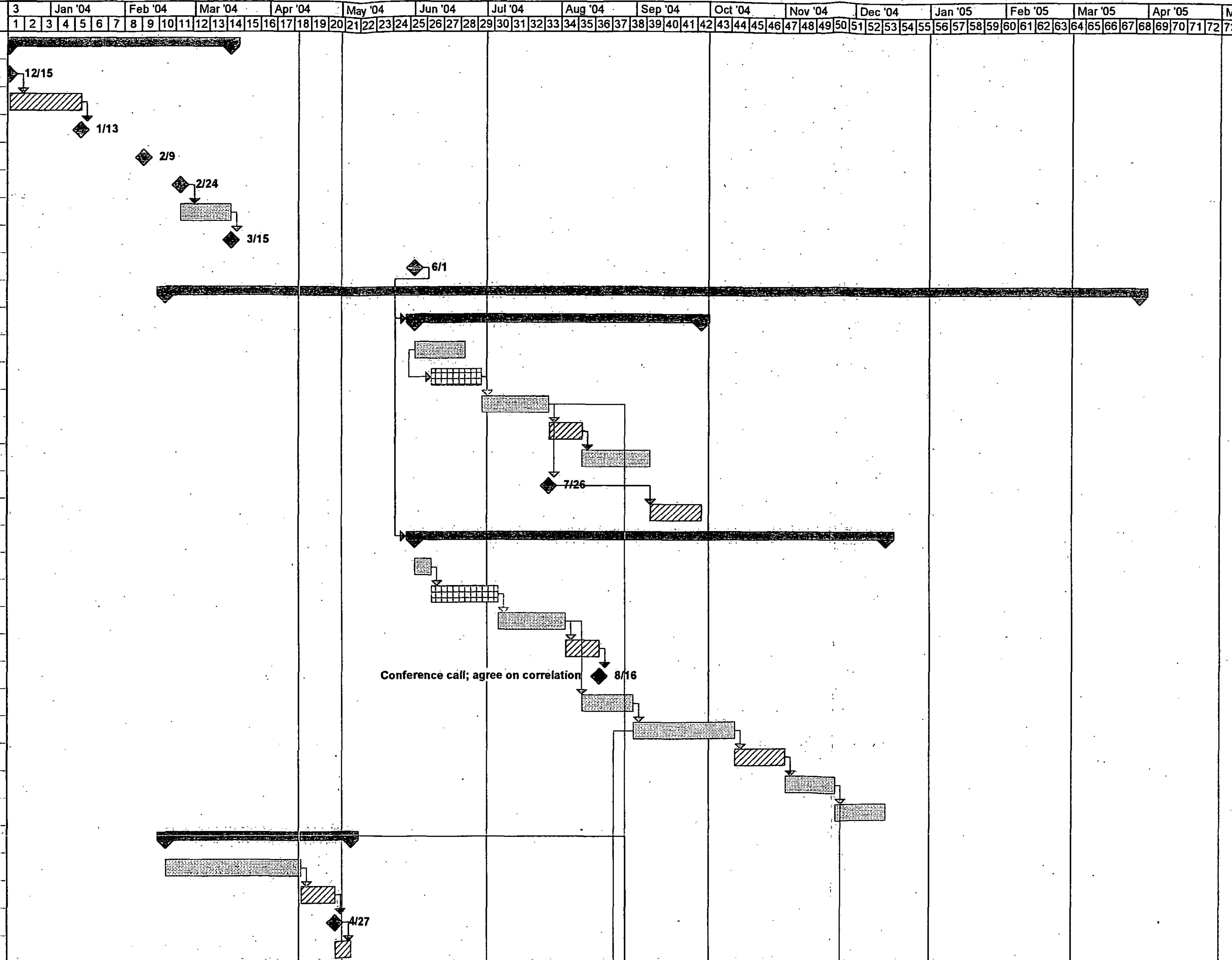
KM/WHITE KING REMEDIAL DESIGN/OR

DRAWING NO. 0331398400fg01.fh11 DATE 04/13/04 DRAWN BY AMP

Golder Associates

Figure 2-2. Remedial Design Schedule - White King / Lucky Lass Mines Superfund Site

ID	Task Name	Duration	Predecessors
1	**Remedial Design (RD) Workplan**	66 days	
2	Submit revised draft RD Workplan	0 days	
3	Review by agencies	22 days	2
4	Meeting with agencies	0 days	3
5	Additional agency comments received	0 days	
6	Comment responses to EPA	0 days	
7	Final comment resolution	3 wks	6
8	RD Workplan approval by EPA expected	0 days	7
9	**Weather suitable for fieldwork (ASSUMED)**	0 days	
10	**Remedial Design**	289 days	
11	**Geotechnical Investigations**	85 days	9
12	Geotechnical fieldwork	3 wks	
13	Laboratory analyses	3 wks	12SS+1 wk
14	Prepare geotechnical data report	4 wks	13
15	Review by agencies	2 wks	14
16	Finalize geotechnical data report	4 wks	15
17	Identify tree removal footprint	0 days	14
18	Tree removal by USFS	3 wks	17FS+6 wks
19	**Gamma Survey**	140 days	9
20	Gamma survey correlation fieldwork	1 wk	
21	Gamma survey correlation laboratory analyses	4 wks	20
22	Prepare gamma survey correlation report	4 wks	21
23	Review by agencies	2 wks	22
24	Conference call; agree on correlation	0 days	23
25	Conduct gamma survey (2 units)	15 days	22FS+1 wk
26	Prepare gamma survey data report	6 wks	25
27	Review by agencies	3 wks	26
28	Respond to agency comments	3 wks	27
29	Finalize gamma survey data report	3 wks	28
30	**30% Design**	55 days	
31	Prepare design documents	8 wks	
32	Review by agencies	2 wks	31
33	Review meeting with EPA	0 days	32
34	Review by agencies	1 wk	33

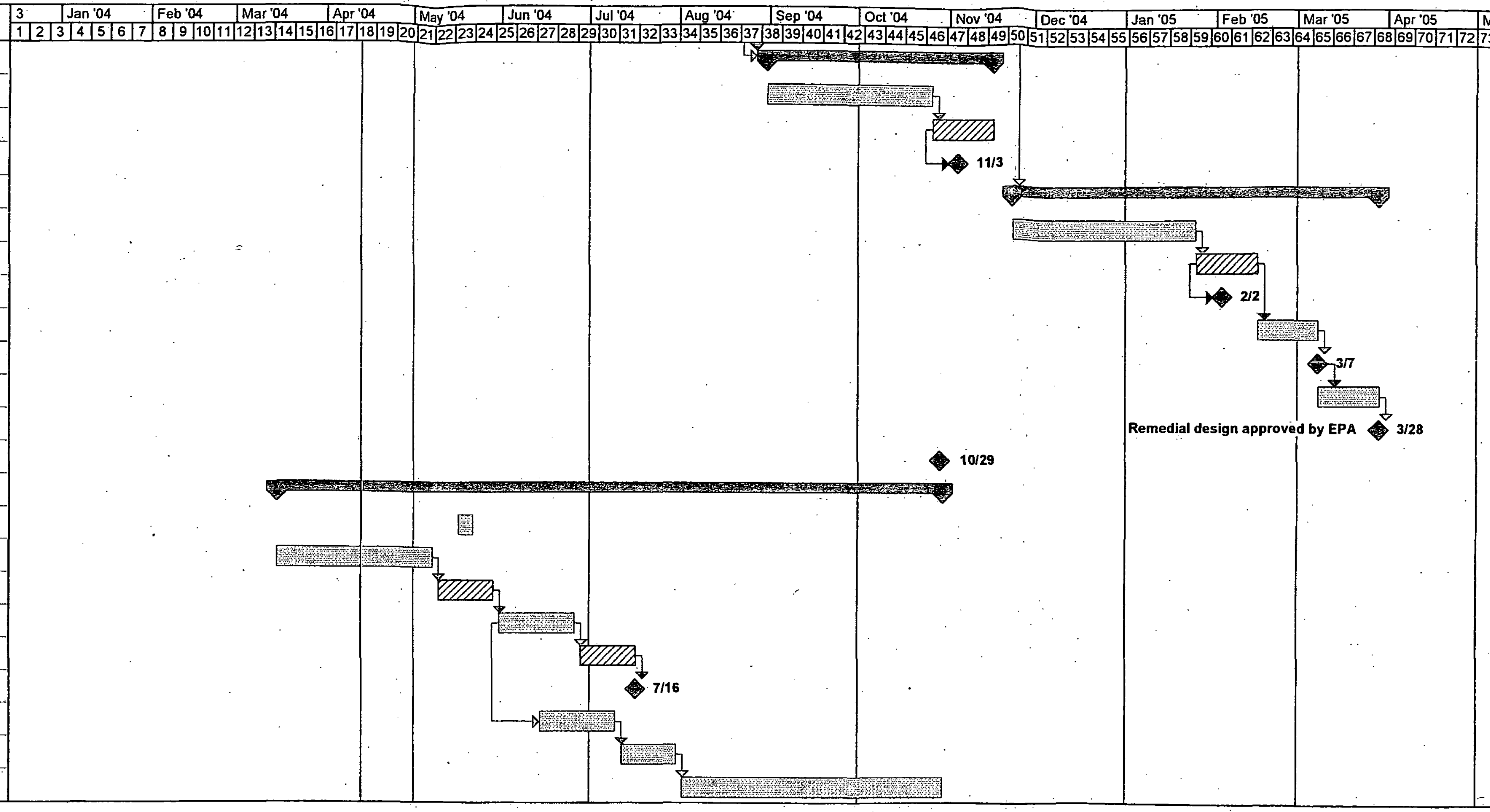


#033-1398

Schedule as of: April 12, 2004

Figure 2-2. Remedial Design Schedule - White King / Lucky Lass Mines Superfund Site

ID	Task Name	Duration	Predecessors
35	**Intermediate Design**	55 days	30,14,26SS
36	Prepare design documents	8 wks	
37	Review by agencies	3 wks	36
38	Review meeting with EPA	0 days	37SS+7 days
39	**Prefinal and Final Design**	90 days	28
40	Prepare prefinal (90%) design documents	9 wks	
41	Review by agencies	3 wks	40
42	Review meeting with EPA	0 days	41SS+7 days
43	Respond to agency comments	3 wks	41
44	Meeting with agencies	0 days	43
45	Prepare final (100%) design documents	3 wks	44
46	Remedial design approved by EPA	0 days	45
47	**Contractor site visit(s) completed**	0 days	
48	**2004 Preparatory Fieldwork**	165 days	
49	Make wet-weather field observations	1 wk	
50	Prepare preliminary combined design & workplan	8 wks	
51	Review by agencies	3 wks	50
52	Revise per comments and field observations	4 wks	51
53	Review by agencies	3 wks	52
54	Design-workplan approved by EPA	0 days	53
55	Select contractor	4 wks	52SS+2 wks
56	Contracting	3 wks	55
57	Mobilization and Construction	13 wks	56



#033-1398

Schedule as of: April 12, 2004

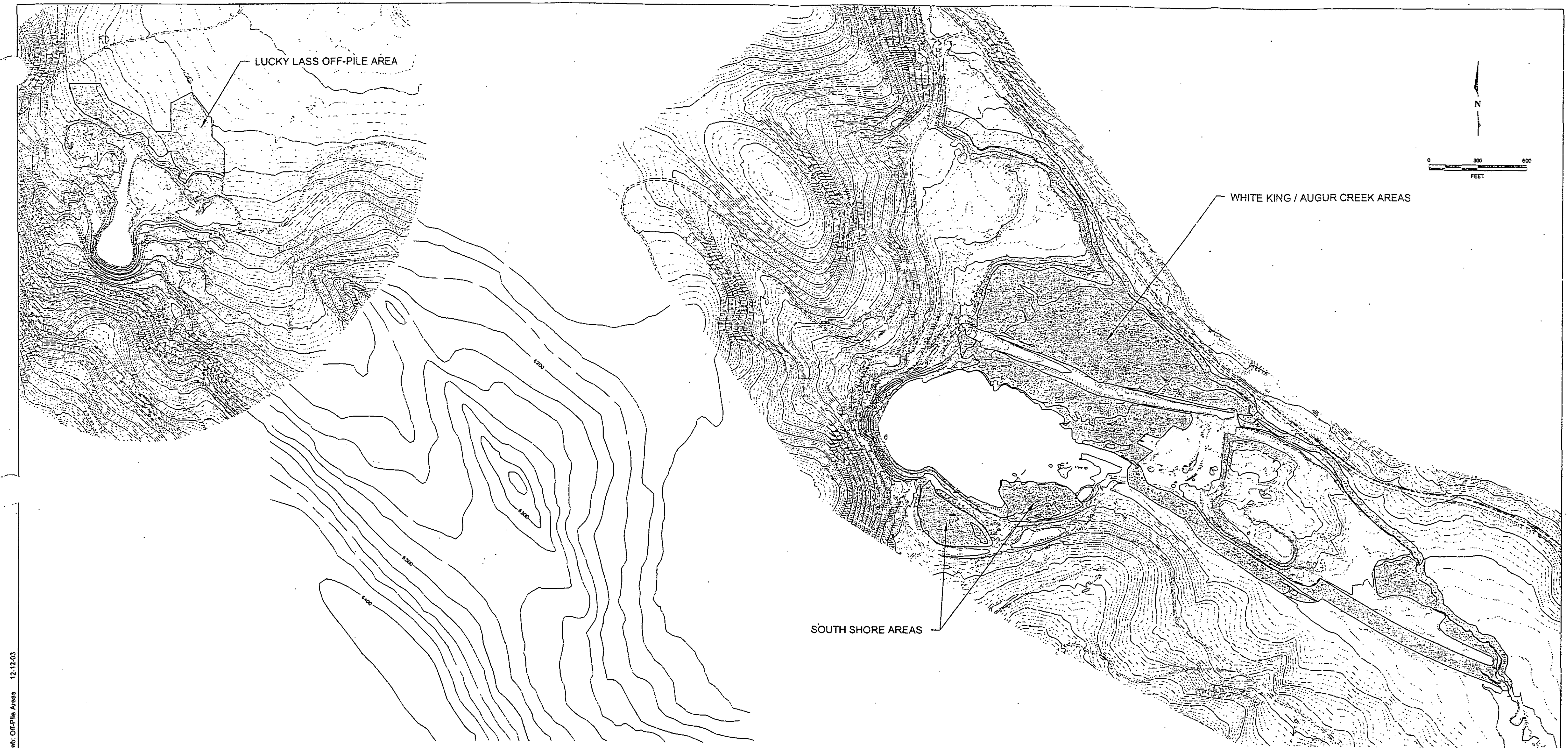


FIGURE **3-1**

EXPECTED MAXIMUM EXTENT OF GAMMA SURVEY

WHITE KING - LUCKY LASS REMEDIATION / OR

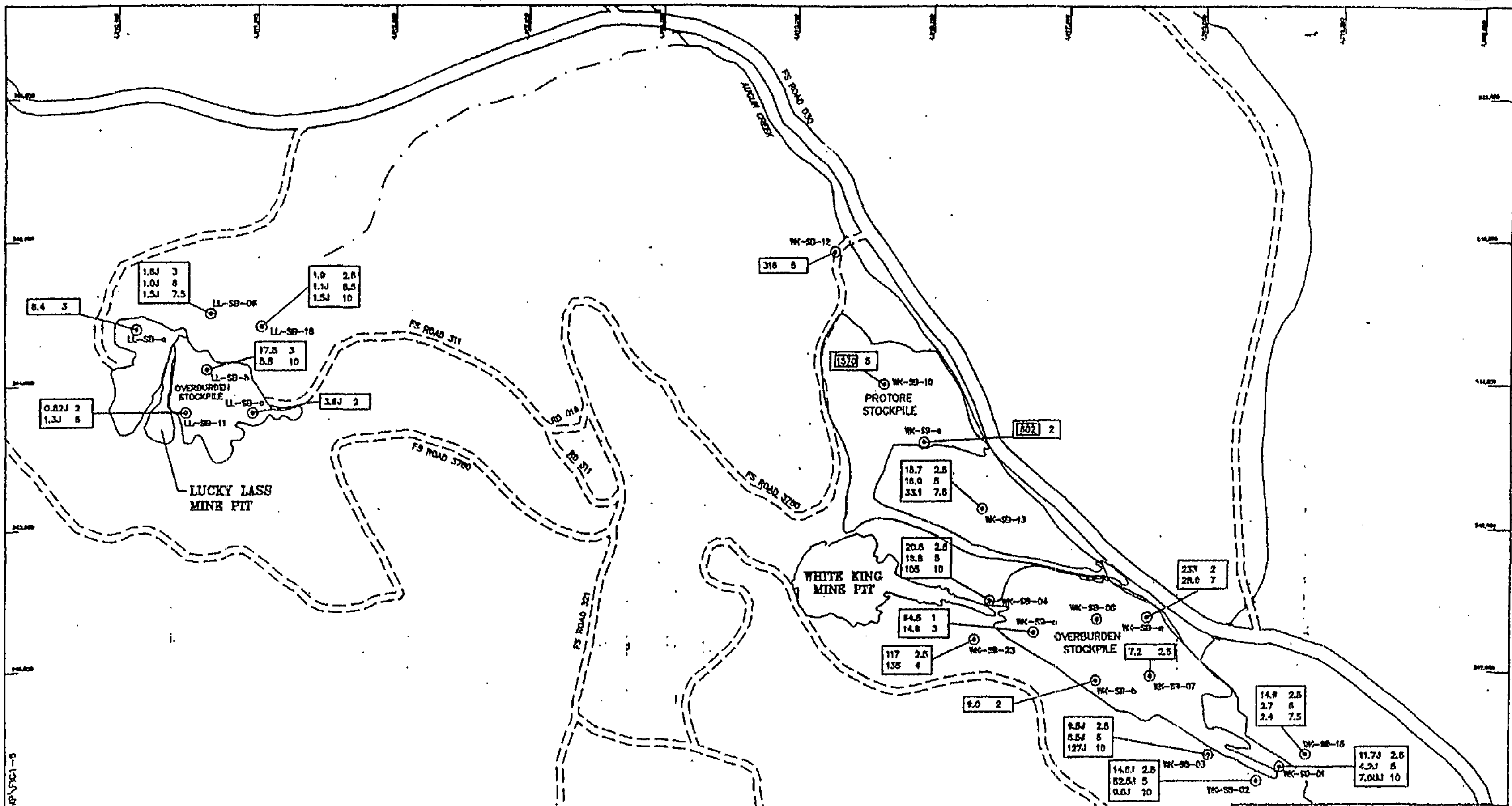
Golder Associates

C:\DATA\FS\S\0331398\...\Mine\Drawings\Figure 3-1 Off-pile.dwg Tab: Off-Pile Areas 12-12-03

Appendix A

APPENDIX A

FIGURES FROM THE FEASIBILITY STUDY



EXPLANATION

RI DATA

CONCENTRATIONS EXCEED PRGs PRESENTED IN SECTION 2.
ARSENIC PRG AT WHITE KING MINE = 442 mg/kg
ARSENIC PRG AT LUCKY LASS MINE = 38 mg/kg

NOTES: CONCENTRATIONS ARE PRESENTED ACCORDING TO DEPTH IN THE FOLLOWING MATRIX:

CONC	FT. BGS
0.25	2.5
1.50	10

BGS = BELOW GROUND SURFACE. FOR STOCKPILES, THE PILE/NATIVE SOIL INTERFACE IS THE GROUND SURFACE.

J ESTIMATED

NOTE: PRE-RI SAMPLE LOCATIONS WERE ESTIMATED BASED ON THE RI WORK PLAN FIGURES.

N

0 700
SCALE IN FEET

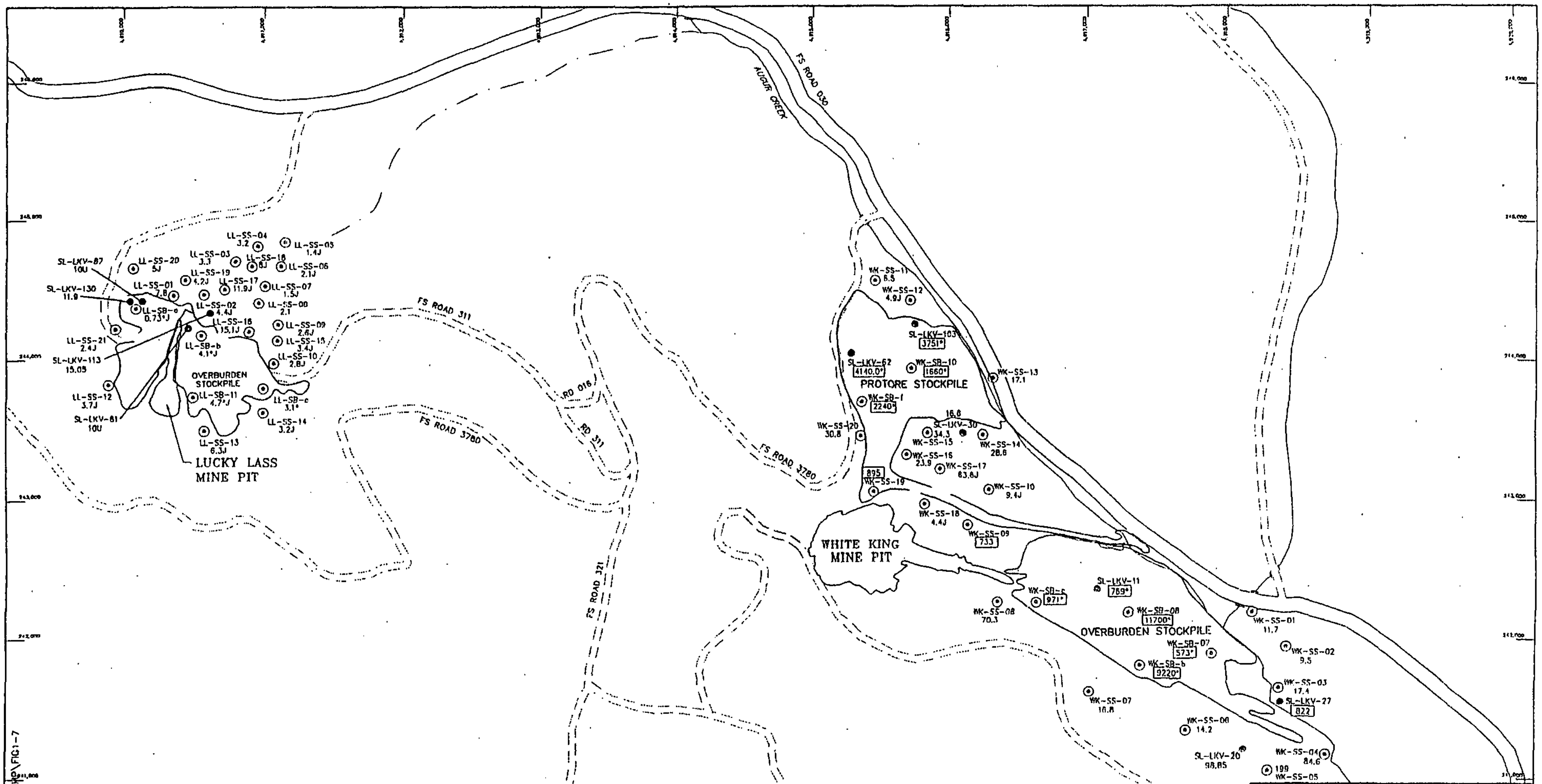
WESTON
MANAGERS DESIGNERS/CONSULTANTS

KERR–McGEE CORP.

WHITE KING / LUCKY LASS MINES SITE
LAKEVIEW, OREGON

SUBSURFACE SOIL CONCENTRATIONS 1 to 10ft BGS ARSENIC (mg/kg)

FIGURE 1–7



CONCENTRATIONS EXCEED PRGn PRESENTED IN SECTION 2.
ARSENIC PRG AT WHITE KING MINE = 442 mg/kg
ARSENIC PRG AT LUCKY LASS MINE = 38 mg/kg

N

0 700
SCALE IN FEET

WESTON®
MANAGERS DESIGNERS/CONSULTANTS

NOTE: PRE-RI SAMPLE LOCATIONS WERE ESTIMATED BASED ON THE RI WORK PLAN FIGURES.

SOURCE: DAMES & MOORE, 1995

EXPLANATION

- ⊙ APPROXIMATE LOCATION OF RI SURFACE SOIL SAMPLE
- ● PRE-RI LOCATION
- * CONCENTRATIONS WERE TAKEN FROM SAMPLES COLLECTED AT THE 2.5 FT. DEPTH INTERVAL BECAUSE SURFACE SOIL CONCENTRATIONS WERE NOT AVAILABLE.
- U UNDETECTED
- J ESTIMATED

KERR–McGEE CORP.

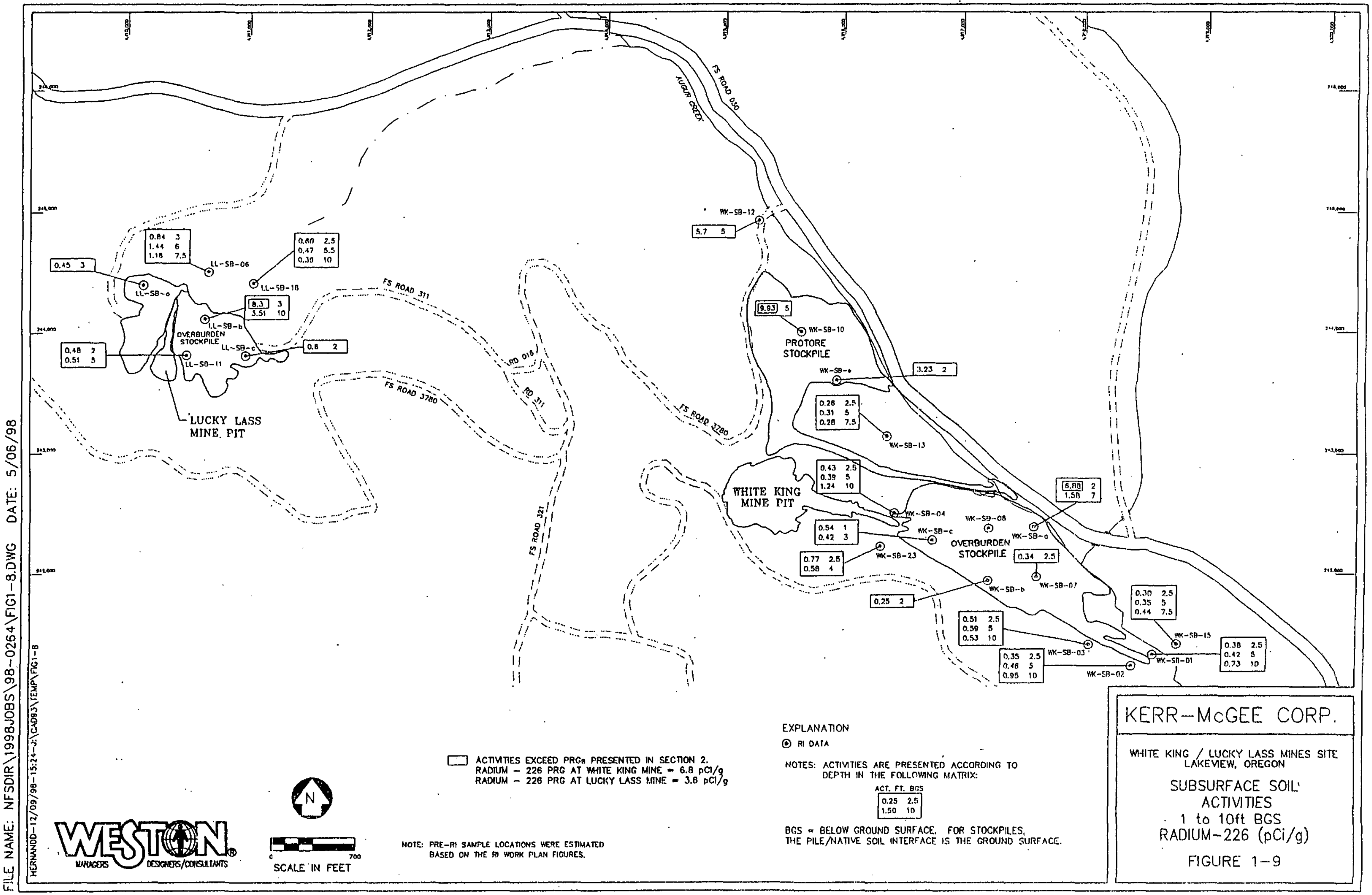
WHITE KING / LUCKY LASS MINES SITE
LAKEVIEW, OREGON

SURFACE SOIL
CONCENTRATIONS
ARSENIC (mg/kg)

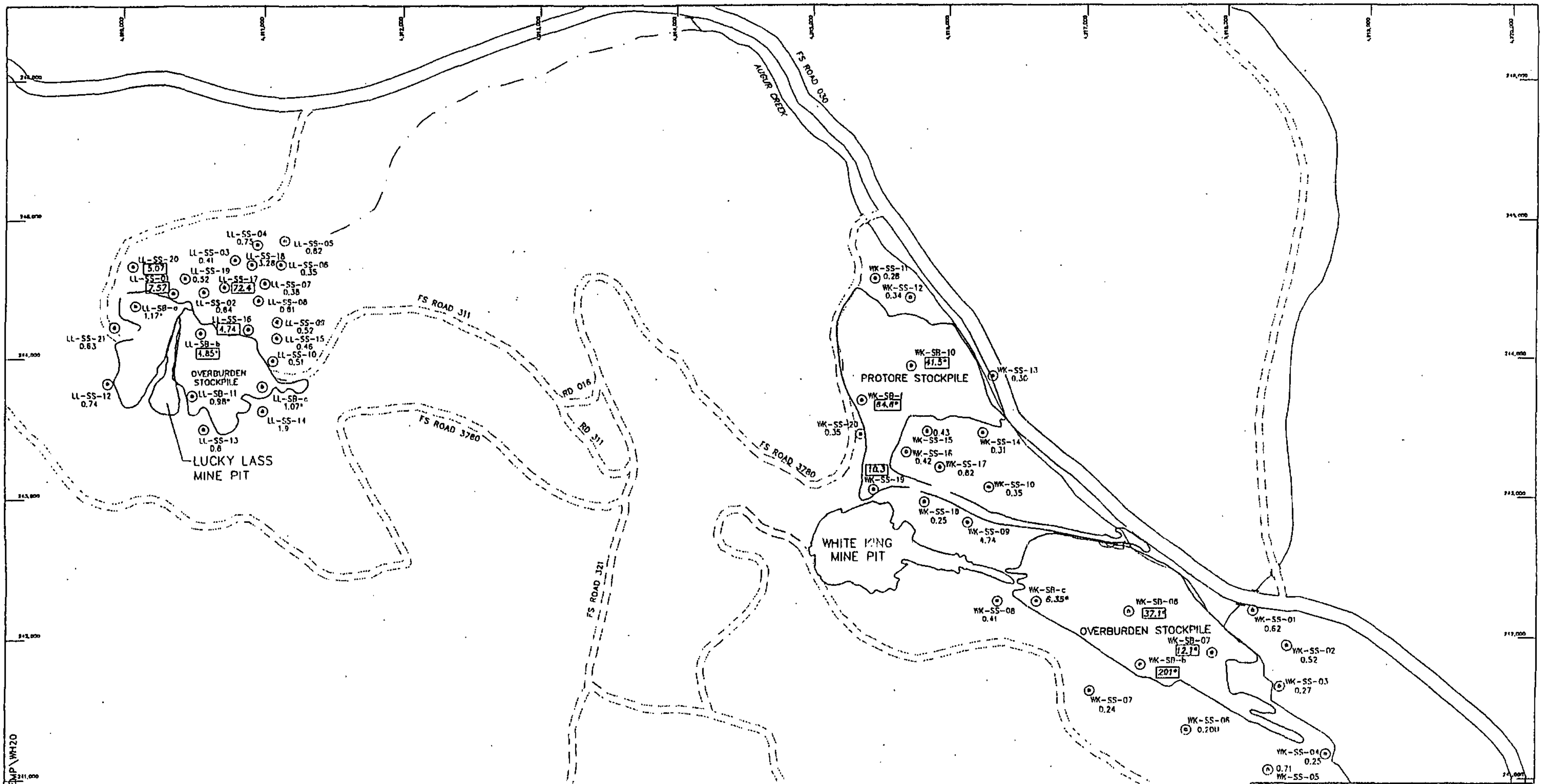
FIGURE 1–8

HERNANDD–12/09/98–15:22–J:\CAD93\TEMP\FIG1-7

FILE NAME: NFSDIR\1998JOBS\98-0264\FIG1-7.DWG DATE: 5/06/98



FILE NAME: NFSDIR\1998JOBS\98-0264\FIG1-8.DWG DATE: 5/06/98



ACTIVITIES EXCEED PRGs PRESENTED IN SECTION 2.
RADIUM - 226 PRG AT WHITE KING MINE = 6.8 pCi/g
RADIUM - 226 PRG AT LUCKY LASS MINE = 3.6 pCi/g

NOTE: PRE-RI SAMPLE LOCATIONS WERE ESTIMATED BASED ON THE RI WORK PLAN FIGURES.

SOURCE: DAMES & MOORE, 1995

N

0 700
SCALE IN FEET

EXPLANATION

⊙ APPROXIMATE LOCATION OF RI SURFACE SOIL SAMPLE

* ACTIVITIES WERE TAKEN FROM SAMPLES COLLECTED AT THE 2.5 FT. DEPTH INTERVAL BECAUSE SURFACE SOIL ACTIVITIES WERE NOT AVAILABLE.

U UNDETECTED

WESTON® MANAGERS DESIGNERS/CONSULTANTS

HERNANDD-12/09/98-15:26-J:\CAD93\TEMP\WH20

KERR–McGEE CORP.

WHITE KING / LUCKY LASS MINES SITE
LAKEVIEW, OREGON

SURFACE SOIL
ACTIVITIES
RADIUM–226 (pCi/g)

FIGURE 1–10

APPENDIX B

RESUMES OF KEY PERSONNEL

TO BE PROVIDED IN FINAL REPORT

Appendix C

APPENDIX C

FIELD INVESTIGATION REPORT OUTLINE

Field Investigation Report Outline

1 – Introduction [summarize data needs, reference remedial design Workplan]

2 – Field Investigations [sampling methods, locations (include maps), sample collection]

3 – Laboratory Testing [laboratory, test types, number, methods. Summarize results in tables, include complete data in appendices. Separate subsections for geotechnical and chemical.]

4 – Discussion [discuss suitability of materials for intended use. Adequacy of volumes. Other considerations for design or construction (e.g., wet-weather impacts)]

5 – References

Appendix – Test Pit Logs

Appendix – Laboratory Data

Appendix D

APPENDIX D

DESIGN REPORT OUTLINE

Design Report Outline

1 – Introduction [design objectives, list of main design features]

2 – Erosion and Sediment Control

3 – Earthworks [borrow sources, placement requirements]

4 – Surface Water

5 – Restoration

6 – White King Pond Highwall Seeps

7 – White King Pond Neutralization

Appendix – Construction Drawings

Appendix – Specifications

Appendix – Calculations

Appendix E

APPENDIX E

CONSTRUCTION QUALITY ASSURANCE PLAN OUTLINE

Construction Quality Assurance Plan Outline

1 – Introduction [purpose and scope]

2 – Project Organization [responsibility and authority (include org chart), project meetings]

3 – Personnel Qualifications [CQA Personnel]

4 – Inspection and Testing Activities [separate sections for each major project feature, summarize quantitative testing (if any) and frequencies in table, visual removal criteria]

5 – Documentation [daily reports, data sheets, non-conformances, design changes and clarifications, progress reports, final report]

6 - References

Appendix F

APPENDIX F

QUALITY ASSURANCE PROJECT PLAN (QAPP)

REVISED DRAFT

QUALITY ASSURANCE PROJECT PLAN FOR SOIL, SEDIMENT, AND SURFACE WATER MONITORING AT THE WHITE KING / LUCKY LASS MINES SUPERFUND SITE

Revision -0-

Prepared for:

Kerr-McGee Chemical Worldwide LLC
Western Nuclear Inc.
Fremont Lumber Co.

Prepared by:

Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, Washington 98052

Lee K. Holder, P.E.
Project Manager

Thomas Stapp
Environmental Project Chemist

December 12, 2003

033-1398.200
QAPP 2003-12-12.doc

TABLE OF CONTENTS

LIST OF TABLES

1.0 PROJECT DESCRIPTION

1.1 Purpose

This Quality Assurance Project Plan (QAPP) was prepared for the White King / Lucky Lass Mines Site by Golder Associates Inc. (Golder) to support field investigation activities associated with remedial design and biotic investigations. This QAPP provides procedures for making accurate measurements and obtaining representative, accurate, and precise analytical data.

1.2 Site Description

A description of the White King / Lucky Lass Mines site is provided in Section 1 of the Remedial Design Workplan.

1.3 Sampling Program Design

The sampling locations and frequency, sampling procedures, and analyses to be performed are presented in the Remedial Design Workplan and the White King Pond and Augur Creek Study Workplan.

2.0 PROJECT ORGANIZATION

2.1 Organizational Structure

The organizational structure for management, quality assurance, and field activities for the White King / Lucky Lass Mine site is established in Section 2 of the Remedial Design Workplan. Contact information for Golder Project Management and a synopsis of duties for each organizational element are provided as follows:

	Project Manager
Contact:	Lee Holder
Company:	Golder Associates Inc.
Address:	18300 NE Union Hill Road, Suite 200
	Redmond, Washington 98052-3333
Telephone:	(425) 883-0777
Facsimile:	(425) 882-5498
E-Mail:	lholder@golder.com

Project Manager

The Project Manager is responsible for planning and executing all environmental sampling and analysis and for preparation of analytical data reports, including submittals to EPA. The Project Manager identifies the specifications for, and administers the subcontracts for laboratory analysis. He also provides information to guide regulatory requirements and reviews aspects of Quality Control requirements. Workplan tasks, referenced method quantitation limits, regulatory compliance levels, and other pertinent documents are reviewed and assessed to determine if data quality objectives are being met.

Principal-in-Charge

The Principal-in-Charge will provide high-level management oversight, senior review, and quality control for the project. He will ensure that the necessary resources are available for successful project execution.

Health & Safety Officer

The Health and Safety Officer is responsible for developing the site Health and Safety Plan (HASP) and communicating the key elements of on-site safety to the field personnel, including personal protective measures and equipment, emergency preparedness, and incident protocol.

Remedial Design Task Leader

The Remedial Design Task Leader is responsible for engineering services required for remedial design activities associated with the White King / Lucky Lass site.

White King Pond and Augur Creek Study Task Leader

The White King Pond and Augur Creek Task Leader is responsible for determining the ability for White King Pond to support aquatic life and the potential for bioaccumulation of contaminants of concern by biota within White King Pond. Related objectives include quantifying the biologic community, and evaluating the effect of pH neutralization on White King Pond. In addition, the task leader will be responsible for pre-remedial action baseline sediment chemistry data collection for Augur Creek.

Chemist/Validator

The Chemist/Validator reports to the Project Manager and task leaders. He/she is responsible for coordinating with the offsite laboratories to obtain required analyses, and for sample tracking, chain of custody, and other sampling and analysis documentation. The Chemist/Validator maintains the data center files, including tabulating, compiling, and archiving data. The Chemist/Validator is responsible for the review and validation of laboratory analysis reports.

Field Sampling Personnel

The Field Sampling Personnel report to the task leaders. The Field Sampling Personnel are responsible for collecting all field samples in accordance with the QAPP and the Remedial Design Workplan and the White King Pond and Augur Creek Study Workplan. In addition, the Field Sampling Personnel are responsible for assembly, organization, and maintenance of all information collected during field activities (including sampling logbook, daily activity logbook, chain-of-custody forms, and field measurements).

2.2 Use of Subcontractors

Qualified laboratories will be retained for standard and specialized chemical tests on soil, water and invertebrate tissue samples as appropriate. Contract laboratories for chemical analysis will have a Quality Assurance Program that conforms to applicable guidelines in documents such as EPA SW-846, EPA QAMS-005/80, EPA QA/G-5, and ISO/IEC Guide 25.

3.0 DATA QUALITY OBJECTIVES

A primary objective of the field sampling activities is to provide analytical data that is of known and defensible quality. Tables QAPP-1.1 through QAPP-1.5 list typical chemical parameters defined for water, and soil/ sediment sampling that may be of interest during the site RD phase. The list of potential organic parameters may include semi-volatile organic compounds, and pesticide/PCBs from the Target Compound List (TCL) of parameters in the *USEPA Contract Laboratory Program Statement of Work for Organics* (EPA, 1999). The list of potential inorganic parameters may include metals from the Target Analyte List (TAL) parameters in the *USEPA Contract Laboratory Program Statement of Work for Inorganics* (EPA, 2000), and selected general chemistry parameters. Benthic macro-invertebrate organisms will be identified during the taxonomic identification task, which requires a sorting and enumeration process. As such, the confirmation of a variety and number of organisms is variable and they will not be enumerated in this document. Constituents will be analyzed using methods as defined in SW-846 (EPA, 1986) and *Standard Methods* (APHA, 1989) as applicable.

The objectives for analytical data quality are defined in terms of the quantitation limits achievable using the referenced analytical methods, and in terms of the resulting goals for precision, accuracy, representativeness, completeness, and comparability of analytical data. Quantitation limits are provided for each analytical parameter in Tables QAPP-1.1 through QAPP-1.5 and are cross-referenced to applicable standard EPA reference methods. The quality objectives established for remedial design are as follows:

- <u>Precision:</u> analytical precision will be reported as required by the governing EPA reference methods cited in Tables QAPP-1.1 through QAPP-1.5.
- <u>Accuracy (Bias):</u> accuracy will be reported as required by the governing EPA reference methods cited in Tables QAPP-1.1 through QAPP-1.5.
- <u>Representativeness:</u> Goals for sample representativeness are addressed qualitatively by the sampling locations and intervals defined in the Workplans. In addition, the use of standard procedures for sample acquisition (as described in Section 4 of this QAPP) will facilitate the collection of representative data.
- <u>Completeness:</u> Completeness is defined as the percentage of valid analytical determinations with respect to the total number of requested determinations in a given sample delivery group; completeness goals are established at 90%. Failure to meet this criterion will be documented and evaluated in the data validation process described in Section 6 of this QAPP, and corrective action taken as warranted on a case-by-case basis.
- <u>Comparability:</u> Approved analytical procedures will require the consistent use of the reporting techniques and units specified by the EPA reference methods cited in Tables QAPP-1.1 through QAPP-1.5 in order to facilitate the comparability of data sets from sequential sampling rounds in terms of their precision and accuracy.

4.0 SAMPLING AND OTHER FIELD PROCEDURES

4.1 Selected Procedures

Technical procedures have been developed to support sampling activities, data validation, and other technical activities. A list of technical procedures applicable to individual activities that may be employed at the sites is provided in Table QAPP-2.

Technical Procedures are provided as guidance to technical personnel and as such, require the specific circumstance of application or the knowledge of the field scientist to appropriately apply the guidance criteria. Some technical procedures may have duplicate or similar information provided in other technical procedures that is nevertheless necessary to provide continuity to the content of the document.

4.2 Variation Request, and Change Control Considerations

Variations from established field procedure requirements may be necessary in response to unique circumstances encountered during sampling activities. Field Sampling Personnel are authorized to implement non-substantive variations based on immediate need, provided that the Project Manager is notified within 24 hours of the variation, and appropriate documentation of the change is executed.

4.3 Sample Quantities, Types, Locations, and Intervals

Sample quantities, types, locations, and intervals for the surface water, sediment, and benthic macro-invertebrate sampling will be as specified in the applicable workplan. Field quality control samples including field blanks, field duplicates, and field split samples will be included in the minimum quantities specified in Section 7 of this QAPP or as specifically stated in the governing technical procedure or ASTM procedure. In the case of benthic macro-invertebrate sampling, the field QC will be limited to collection of replicate samples as a way of assessing the precision of the sampling effort (ASTM E2122-02). Appropriate documentation of the purpose of each sample will be maintained in the field log, and identified by the assigned sample designation; copies will be separately provided to the data validator as necessary (see Section 6 of this QAPP).

4.4 Sample Designation and Labeling Requirements

Sample labels will be attached to each sample container with an assigned field sample number, applied in a chronological sequence during the field activities. One number designation will appear on each sample bottle or container for a unique sample, regardless of the number of bottles and containers collected to represent the multiple analyses to be performed. This will ensure that field samples will remain unambiguously associated with the corresponding field locations. Information on the label will include the following:

- Golder Associates project number
- Sample designation number
- Analytical tests to be performed
- Appropriate preservation steps

- Samplers initials
- Date and time of sample collection.

The sample designation number will be cross-referenced in the field notes to identify the collection location, depth, and other unique sample collection information.

Each sample bottle will identify the laboratory analysis to be performed both in writing on the container, by reference to the container size, and/ or the label attached by the laboratory identifying the preservative added for the appropriate analysis. Number designations and assigned laboratory analyses will be recorded on the field report forms shown in the applicable sampling procedures, as well as on the chain of custody/sample analysis request form supplied by the analytical laboratory.

4.5 Sample Container Type, Volume, Preservation, and Handling Requirements

All sample containers, container preparation services, preservatives, trip blanks, and sample coolers will be provided by the analytical laboratory as part of their agreement for services. If Agency oversight sampling and analysis is to be performed, the Agency representative and their designated laboratory will be responsible for providing sample containers unless arrangement is made with Golder to provide sample containers. Sample container type, volume requirements, preservation requirements, and special handling requirements for the potentially required analyses are listed by analytical category in Table QAPP-3 for water matrix, and in Table QAPP-4 for soil matrix. Special handling and preservation requirements for the macroinvertebrate sampling and tissue preparation for analytical testing are provided in the ASTM Standard document (ASTM E2122-02).

Samples for geotechnical testing will be handled, contained and preserved in a manner specified in the governing ASTM or technical procedures.

All samples will be sealed, labeled, properly identified, and submitted to the analytical laboratory under formal chain of custody requirements as described in Section 4.6 of this QAPP.

4.6 Chain of Custody Considerations

All samples obtained during the course of this investigation will be controlled as required by procedure TP-1.2-23 *Chain of Custody*. Chain of custody forms (see Exhibit C in TP-1.2-23) will be completed for each shipment of samples as described in the procedure. Sample analysis request forms supplied by the analytical laboratory or chain of custody forms will be completed instead of Sample Integrity Data Sheets; such forms will specifically identify the applicable reference methods specified in Tables QAPP-1.1 through QAPP-1.5 as appropriate for each individual sample. All laboratory sample tracking procedures will ensure traceability of analytical results to the original samples through the analytical method referenced on the chain of custody and the laboratory applied tracking number. Each laboratory applied tracking number will be traceable to a unique sample designation number as specified in Section 4.4.

4.7 Sampling Equipment Decontamination

All non-dedicated sampling equipment which comes in contact with sample will be thoroughly cleaned prior to each sampling event to prevent cross-contamination between samples and to ensure accurate representation of analytes of interest in each sample interval. Personnel performing decontamination will wear rubber gloves, face or eye shields, and such other safety equipment as directed by the project-specific Health and Safety Plan. Samplers and sampling tools will be disassembled as necessary and placed in clean, dedicated drums or troughs fitted with gravity drains.

4.7.1 Organic Parameter Equipment Decontamination

Non-dedicated equipment will be cleaned with a brush and non-phosphate detergent-water mixture such that all visible solid matter is removed. A second wash will be performed after the detergent-water wash. For samples requiring organic analyses, non-dedicated equipment will be rinsed with organic-free distilled/deionized water, then rinsed with reagent grade methanol, and finally given a second rinse of organic-free distilled/deionized water. Should tars or other visible organic matter remain on the non-dedicated equipment after the detergent-water wash, a methanol soaked towel will be used to attempt cleanup, and then the full complement of wash procedures repeated. If the non-dedicated equipment retains visible matter after the previously stated actions, the equipment will be retired from the sampling procedures and not used again. Samplers will be reassembled using clean rubber gloves; all decontaminated samplers and sampling tools will be sealed in clean plastic bags pending their next use. All wash and rinse fluids will be transferred to storage drums for short term storage on-site, pending characterization and final disposal at the direction of the Project Manager.

4.7.2 Inorganic Parameter Equipment Decontamination

For samples requiring inorganic analyses, non-dedicated equipment will be rinsed with organic-free distilled/deionized water, then rinsed with a dilute solution of hydrochloric acid, and finally given a second rinse of organic-free distilled/deionized water. Samplers will be reassembled using clean rubber gloves; all decontaminated samplers and sampling tools will be sealed in clean plastic bags pending their next use. All wash and rinse fluids will be transferred to storage drums for short term storage on-site, pending characterization and final disposal at the direction of the Project Manager.

4.7.3 Macroinvertebrate Equipment Decontamination

Equipment decontamination for preparation of the macroinvertebrate tissues will be as specified in the ASTM Standard document (ASTM E2122-02). Sampling and homogenizing equipment will be handled using clean rubber gloves; all decontaminated tools will be sealed in clean plastic bags pending their next use. All wash and rinse fluids will be transferred to dedicated storage containers for short term storage on-site, pending characterization and final disposal at the direction of the Project Manager.

4.8 Calibration Requirements

Calibration of all measuring and test equipment, whether in existing inventory or purchased for this investigation, will be controlled as required by procedure QP-11.1 *Calibration and Maintenance of Measuring and Test Equipment*, or, in the case of portable radiometric survey meters, technical procedures 378-2 and 379-2. Lease equipment will require certifications or other documentation demonstrating acceptable calibration status for the entire period of use for this project. Field calibration requirements will be in compliance with the technical procedure describing the instrument's use and/or with the manufacturer's instructions issued with the equipment.

Method-specific and analytical equipment-specific calibration requirements practiced by individual analytical laboratories selected for subcontract services (Section 2.2 of this QAPP) are addressed within the laboratory QA plans.

5.0 ANALYTICAL PROCEDURES

Tables QAPP-1.1 through QAPP-1.5 cross-references the analytes of interest of this investigation to the standard reference methods and method detection limits that will be established as contractual requirements between Golder and the subcontracted analytical laboratories.

5.1 Field Screening Analytical Procedures

A gamma survey technique will be used to screen area wide soil conditions, test pit locations, or prepared soil aliquots for radioactivity. The gamma survey will utilize portable survey meters to detect gamma emanation from a variety of isotopes. The field tests will define the number of samples selected for collection and/ or compositing actions, and thus will ultimately determine the number of laboratory based analytical tests to be performed. Technical procedures for the use, calibration and calibration check status of field portable instruments are provided in the Appendices. These procedures include:

- Portable Survey Instrument Operability Checks (376-6)
- Calibration Check Of Vendor-Calibrated Portable Survey Meters (378-2)
- Calibration of the Ludlum Scaler Ratemeter (379-2)

Copies of the technical procedures are listed in Table QAPP-2 and full texts are provided in Appendix F of the Remedial Design Work Plan document.

5.2 Laboratory Analytical Procedures

Laboratories selected to support the organic, inorganic and isotope analyses for soil, water, and biota samples, will conform to EPA SW846 methods, Prescribed Procedures for Measurement of Radioactivity in Drinking Water, or radiochemical procedures from The Department of Energy "EML Procedures Manual" as appropriate. Most laboratories have developed their own Standard Operating Procedures (SOPs) associated with the Methods provided in QAPP Tables 1.1 through 1.5. These procedures are acceptable for use provided they are developed in accordance with an established laboratory QA/QC plan that provides precision and bias data meeting EPA acceptance criteria for acceptable data quality. Quality control data must be presented with the analytical data for each Sample Delivery Group submitted to the lab, at a minimum of those QC criteria specified in Section 6.1 of the QAPP. Specific analytical tests may include the following:

5.2.1 <u>Organic Analyses</u>

EPA 8270C	Semivolatiles.
EPA 8081A	Organochlorine Pesticides
EPA 8082	Polychlorinated biphenyls

5.2.2 <u>Inorganic Analyses</u>

EPA 200.7 / 6010B	Total and Dissolved Metals
EPA 200.8 / 6020A	Total and Dissolved Metals

EPA 200.9 / 7060 Total and Dissolved Arsenic
EPA 245.1 / 7470A Total and Dissolved Mercury

5.2.3 <u>Radiochemical Analyses</u>

EPA 9310 Gross Alpha and Beta
EPA 9320 Radium-228
EPA 900.0 Gross Alpha and Beta Radioactivity
EPA 901.1 Gamma Emitting Radionuclides
EPA 903.1 Radium-226, Radium Emanation Technique
EPA 904.0 Radium-228
EPA 200.8 ICP/MS for Uranium, Thorium

5.3 Macroinvertebrate Tissue Analysis

The macroinvertebrate tissue sampling will be performed in the field. Preparation procedures for the tissue samples and quality control criteria associated with the sampling and preparation are as stated in the ASTM Method for conducting in-situ field bioassays (ASTM E2122-02). The analytical preparation method for analysis of metal content in tissue will be EPA 3010A; *Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by Flame Atomic Absorption or Inductively Coupled Plasma (ICP) Spectroscopy.* EPA Method 6010B for moderate level metal content or EPA Method 6020 for low level metal content will be employed for the analysis of metals in tissue samples. Quality control criteria for tissue preparation will be as outlined in the ASTM method and the laboratory will be responsible for providing appropriate QC data with the analytical data for each Sample Delivery Group of tissue samples submitted to the lab, at a minimum of those QC criteria specified in Section 6.1 of the QAPP.

5.4 5.4 Geotechnical Testing

Geotechnical procedures are identified to support field collection of soil to track soil particle sizing, density tests, and stability issues at the site. ASTM methods represent the procedures to follow in meeting the geotechnical needs. The ASTM methods are presented below and in Table QAPP-1.1, but are presented as reference documents only and are not duplicated in this QAPP.

- C88 Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

- C535 Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

- D422 Standard Test Method for Particle-Size Analysis of Soils

- D1140 Standard Test Methods for Amount of Material in Soils Finer Than the No. 200 (75-um) Sieve

- D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort

- D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- D5084 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

6.0 DATA REDUCTION, VALIDATION, AND REPORTING

6.1 Requirements for Field Gamma Survey Data

Data collection for the gamma survey will be required to determine correlation criteria to the laboratory based analyses for radioactive isotopes of concern. The gamma survey data will include instrument calibration checks, operational checks, survey measurement locations, and the instrument results. Copies of the field data will be routed to the Project Manager for data assessment purposes and to the permanent project records. Details for field gamma survey data reduction, validation, and reporting are provided in Section 3.1 of the Remedial Design Workplan.

6.2 Requirements for Field Biota Data

Data collection for the macroinvertebrate selection and sample processing will be as required according to the ASTM standard procedure (ASTM E2122-02). Copies of the field data will be routed to the Project Manager for data assessment purposes and to the permanent project records. Details for data reduction, validation, and reporting associated with the field biota sample collection and processing are provided in Section 3.1 of the Remedial Design Workplan.

6.3 Requirements for Geotechnical Data

The geotechnical data reduction, validation, and reporting will be as prescribed in the Golder Technical Procedures and in the ASTM procedures referenced in Section 5 of this QAPP. Copies of the data and validation reports will be routed to the Project Manager for data assessment purposes and to the permanent project records.

6.4 Requirements for Laboratory Chemical Analytical Data

All analytical data packages submitted by the analytical laboratories will meet the requirements of a standard laboratory Level III report package. The analytical laboratories include those selected for organic, inorganic, general chemistry, and radiochemical analyses. Most laboratories identify the Level III reporting as a "data validation package", and the major elements of this report package will include the following:

- A case narrative of the data package deficiencies or exceptions, and sample receipt "condition found" record, noting dates of sample receipt, and chain-of-custody documentation;
- Analytical hard copy (paper) results with raw data for each sample containing neat or dilution adjusted results for all analytes/constituents requested on the chain of custody form, request for analysis, or purchase order;
- Analytical quality control results and summary documents for laboratory method blanks, duplicates, laboratory control samples, blank spike/blank spike duplicates, matrix spike/matrix spike duplicates, serial dilutions, surrogates, and internal standards;
- Sample preparation summary data including dates of sample extraction and analysis, analytical methods, and appropriate detection or reporting limits.

All data packages for all analytical parameters will be reviewed and approved by the analytical laboratory's QA Officer prior to submittal for validation..

6.5 General Validation Requirements

All analytical data packages from each sample delivery group will be validated by the detailed review and calculation over-check processes described in *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2002), *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999), and *USEPA Contract Laboratory Program National Functional Guidelines for Low Concentration Organic Data Review* (EPA, 2001). Data validation work will be performed to ensure that the laboratory has met all contractual requirements, all applicable reference method requirements, and the data quality objectives discussed previously in Section 3 and Tables QAPP-1.1 through QAPP-1.5. Validated data will be stored as indicated in procedure TP-2.2-12 *Analytical Data Management* for each sample delivery group. A sample delivery group may be interpreted as a group of twenty samples, or the group of samples delivered to the laboratory in a single week, which ever occurs first.

The data validator will document all contacts made with the laboratory to resolve questions related to the data package. The data validator will prepare a technical report or provide a summary checklist documenting the evaluation of laboratory blanks, field blanks, equipment blanks, duplicates, matrix spikes/matrix spike duplicates, laboratory control samples, calibration data (as applicable for the specified method), and any re-qualification of analytical results required as a result of the validation exercise. The validation report, laboratory contact documentation, copies of the laboratory sample concentration reports, and the as-reviewed laboratory data package will be routed to the Project Manager for data assessment purposes and to the permanent project records.

6.6 Data Assessment Procedures

The data will be validated by project personnel in compliance with EPA guidelines and then reported to the Golder Project Manager. Data assessment will then be performed as described in the Remedial Design Workplan and the White King Pond and Augur Creek Study Workplan. The data will eventually be transferred to EPA in a suitable format.

7.0 QUALITY CONTROL PROCEDURES

All analytical samples will be subject to quality control (QC) measures in both the field and laboratory. The following minimum field quality control requirements apply to all analyses for surface water, groundwater, sediment, and soil samples. These requirements are adapted from *Test Methods for Evaluating Solid Waste* (EPA, 1986; SW-846), as modified by the proposed rule changes included in the *Federal Register* (EPA, 1989).

- Field duplicate samples. Depending on the availability of sufficient sample quantities, field duplicates will be collected at a minimum of one duplicate for each matrix for each period of sampling activity or one duplicate sample for each twenty field samples collected, whichever is more frequent. A "sampling activity period" is identified as one or more field personnel engaged in a specific time of sample collection when one method of sampling is used. The sampling locations for field duplicates are to be determined in the field based upon areas of field identified contaminants, and where volume requirements are sufficient. Duplicate samples will be retrieved from the same sampling location using the same equipment and sampling technique, and will be placed into identically prepared and preserved containers. All field duplicates will be identified with a unique sample designation as specified in Section 4.4 of this QAPP and will be analyzed independently as an indication of gross errors in sampling techniques.
- Equipment blanks. Equipment blanks will consist of pure deionized distilled water washed through decontaminated non-dedicated sampling equipment and placed in containers identical to those used for actual field samples. Equipment blanks may also include a collection of pure deionized distilled water into collection containers when only dedicated equipment is used. Equipment blanks verify the adequacy of sample containers, non-dedicated sampling equipment decontamination procedures, and the proficiency of the field technician to eliminate fugitive contaminants. The equipment blanks will be collected at a location based upon the potential for the presence of field contaminants and at the same frequency as field duplicate samples.
- Trip blanks. Trip blanks consist of pure deionized distilled water added to one clean volatile organic sample vial, accompanying each batch of samples shipped during a sampling activity or period. It is not anticipated that samples with volatile parameters will be investigated at the sites, and, therefore, trip blanks will not be collected. However, should this circumstance change, the analyses of the trip blank will be at the Project Manager's discretion.

The internal quality control checks performed by the analytical laboratory shall meet the following minimum requirements:

- Matrix spike and matrix spike duplicate samples. Matrix spike and matrix spike duplicate samples require the addition of a known quantity of a representative analyte of interest to the sample as a measure of recovery percentage. The spike shall be made in a replicate of a field sample or field duplicate sample. Replicate samples are separate aliquots removed from the same sample container in the laboratory. Spike compound selection, quantities, and concentrations shall be described in the laboratories analytical procedures. One sample shall be spiked per analytical batch, or once every 20 samples, whichever is greater.

- Quality control reference samples (check samples). A quality control reference sample shall be prepared from an independent standard at a concentration other than that used for calibration, but within the calibration range. The quality control reference sample is analyzed after the initial calibration and before any samples are analyzed, and shall be run with every analytical batch, or every 20 samples, whichever is greater. Reference samples are required as an independent check on analytical technique and methodology.

8.0 PREVENTIVE MAINTENANCE

All measurement and testing equipment used in the field and laboratory that directly affects the quality of the analytical data shall be subject to preventive maintenance measures that ensure minimization of measurement system downtime. Golder Associates field equipment that is used for on-site direct measurement or sample acquisition will be subject to the calibration and measurement test procedures as described in Technical procedure QP-11.1 *Calibration and Maintenance of Measuring and Test Equipment.* The subcontracted analytical laboratories will be responsible for performing or managing the maintenance of their analytical equipment; maintenance requirements, spare parts lists, and instructions will be incorporated in the laboratory's QA plan.

9.0 DATA MANAGEMENT PLAN

The data management plan addresses the routing and storage of incoming project data.

Laboratory data will be provided to Golder in both hard copy (paper) and electronic format. The paper copy will be routed to the data validator for confirmation of analytical data receipt and subsequent validation activities. The data validator will reserve electronic data until such time as validation actions can be completed and the electronic version of the analytical data updated with qualifier flags as necessary. Validated analytical data packages and diskettes will be routed to the project records for controlled storage, and the validated data will be processed into the analytical database in accordance with guidance in Technical Procedure TP-2.2-12 *Analytical Data Management*. The following items associated with analytical data may be included as deliverables for inclusion into the project archives:

- Analytical data packages and analytical quotes
- Electronic versions of the data package by diskette, or e-mail delivery
- Correspondence with the laboratory by e-mail, telecom, or facsimile transmission associated with analytical data package issues
- Chain of custody and shipping documentation
- Copies of technical field logs and field reports.

10.0 REFERENCES

APHA, 1989, *Standard Methods for the Examination of Water and Wastewater*, 20th Ed.

ASTM D4557-85 *Standard Practice for Collecting Benthic Macroinvertebrates with Surber and Related Type Samplers*, Annual Book of ASTM Standards, Vol 11.02, 1994.

ASTM E2122-02 Standard Guide for Conducting In-situ Field Bioassays With Caged Bivalves, ASTM Book of Standards, Volume 11.05, Subcommittee, E47.01.

ASTM C88 Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM C535 Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

ASTM D422 Standard Test Method for Particle-Size Analysis of Soils

ASTM D1140 Standard Test Methods for Amount of Material in Soils Finer Than the No. 200 (75-um) Sieve

ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort

ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D5084 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

DOE, 4.5.2.3 *Gamma Ray Spectrometry*, EML Procedures Manual, US Department of Energy, 27th Edition, Volume 1, 1990.

EPA, 1979, *Methods for the Chemical Analysis of Water and Waste*, EPA-600/4-79-020.

EPA, 1986, *Test Methods for Evaluating Solid Waste*, SW-846.

EPA, 1989, *Federal Register*, Volume 54, No. 13.

EPA, 1998, *EPA Guidance for Quality Assurance Project Plans*, EPA QA/G-5, (EPA/600/R-98/018), February.

EPA, 1999, *USEPA Contract Laboratory Program Statement of Work for Organics*, OLM04.2, August.

EPA, 1999, *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, OSWER 9240.1-05A-P, PB99-963506, (EPA-540/R-99-008), October.

EPA, 2000, *USEPA Contract Laboratory Program Statement of Work for Inorganics*, ILM04.1, January.

EPA, 2001, *USEPA Contract Laboratory Program National Functional Guidelines for Low Concentration Organic Data Review*, OSWER 9240.1-34, (EPA 540-R-00-006), June.

EPA, 2002, *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, OSWER 9240.1-35, (EPA 540-R-01-008), July.

EPA 1989. *Rapid Bioassessment Protocols for Use in Streams and Rivers - Benthic Macroinvertebrates and Fish*, EPA/440/4-89/001.

EPA 900.0 *Gross Alpha and Gross Beta Radioactivity, Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA-600/4-80-032, August, 1980.

EPA 901.1 *Gamma Emitting Radionuclides, Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA-600/4-80-032, August, 1980.

EPA 903.1 *Radium 226 – Radon Emanation Technique, Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA-600/4-80-032, August, 1980.

EPA 904.0 *Radium 228, Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA-600/4-80-032, August, 1980.

EPA 200.8 *Determination of Trace Elements in Waters and Wastes by ICP/MS*, Environmental Monitoring Systems Laboratory, Office of Research and Development, US EPA, Cincinnati, Ohio, Revision 5.4

EPA 3010A "Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by Flame Atomic Absorption or Inductively Coupled Plasma (ICP) Spectroscopy", *Test Methods for Evaluating Solid Waste*, SW-846.

TABLES

TABLE QAPP-1.1
RADIOMETRIC ANALYSES
Soil and Water Quality Criteria

Name	Symbol	Type	Method	MDA and MDL[c]
Gross alpha activity	--	Water	EPA 9310[a] / 900.0[b]	15 pCi/L
Gross beta activity	--	Water	EPA 9310[a] / 900.0[b]	50 pCi/L
Radium 226	Ra-226	Water	EPA 9320[a] / 903.1[b]	1 pCi/L
Radium 228	Ra-228	Water	EPA 9320[a] / 904.0[b]	1 pCi/L
Potassium 40	K-40	Water	Gamma Spectroscopy (901.1)	Lab Specific
Thorium 232	Th-232	Water	EPA 200.8[d]	0.00002 mg/L
Uranium 234	U-234	Water	Gamma Spectroscopy (901.1)	Lab Specific
Uranium 238	U-238	Water	EPA 200.8[d]	0.00005 mg/L

Notes:
a - USEPA Methods from SW-846 *Test Methods for Evaluating Solid Waste*.
b - EPA Methods from *Prescribed Procedures for Measurement of Radioactivity in Drinking Water,* August 1980.
c - MDA, Minimum Detectable Activity: pCi/L = pico Curie per Liter; MDL, Method Detection Limit: mg/L = milligram per Liter.
d - EPA Method 200.8 *Determination of Trace Elements in Waters and Wastes by ICP/MS,* Rev. 5.4.

Name	Symbol	Type	Method	MDA[b] and MDL[c]
Radium 226	Ra-226	Soil	EPA 9320[a]/ Gamma Spec	0.1 pCi/gm
Radium 228	Ra-228	Soil	EPA 9320[a]/ Gamma Spec	0.2 pCi/gm
Potassium 40	K-40	Soil	Gamma Spectroscopy	Lab Specific
Thorium 232	Th-232	Soil	EPA 200.8[d]	0.05 ug/gm
Uranium 234	U-234	Soil	Gamma Spectroscopy	Lab Specific
Uranium 238	U-238	Soil	EPA 200.8[d]	1 ug/gm

Notes:
a - USEPA Methods from SW-846 *Test Methods for Evaluating Solid Waste*.
b - MDA, Minimum Detectable Activity: pCi/gm = pico Curie per gram.
c - MDL, Laboratory Method Detection Limits: ug/gm = microgram per gram.
d - EPA Method 200.8 *Determination of Trace Elements in Waters and Wastes by ICP/MS,* Rev. 5.4.

TABLE QAPP -1.2
METALS
Soil and Water Quality Criteria

Analytes[aa]	CAS #	Method[a]	CLP Inorganics ILM04.0 CRQL[e] Water ug/L	Laboratory Water PQL[c] ug/L	Laboratory Soil PQL[c] mg/Kg
Aluminum	7429-90-5	200.7 / 6010B	200	100	
Antimony	7440-36-0	200.9 / 6010B	60	3[b]	10
Arsenic	7440-38-2	200.9 / 6010B	10	5	2
Barium	7440-39-3	200.7 / 6010B	200	5	1
Beryllium	7440-41-7	200.7 / 6010B	5	2	0.4
Cadmium	7440-43-9	200.9 / 6010B	5	0.5	1
Calcium	*7440-70-2*	*200.7 / 6010B*	*5000*	*1000*	1.3
Chromium	7440-47-3	200.7 / 6010B	10	10	2
Cobalt	7440-48-4	200.7 / 6010B	50	5	1
Copper	7440-50-8	200.9 / 6010B	25	5	2
Iron	7439-89-6	200.7 / 6010B	100	100	
Lead	7439-92-1	200.9 / 6010B	3	1[b]	2
Magnesium	7439-94-4	200.7 / 6010B	5000	1000	
Manganese	7439-96-5	200.7 / 6010B	15	5	
Mercury	7439-97-6	245.1 / 7470A	0.2	0.2	0.02
Nickel	7440-02-0	200.7 / 6010B	40	10	8
Potassium	7440-50-8	200.7 / 6010B	5000	1000	
Selenium	7782-49-2	200.9 / 6010B	5	2[b]	10
Silver	7440-22-4	200.9 / 6010B	10	1	2
Sodium	7440-23-5	200.7 / 6010B	5000	1000	
Thallium	7440-28-0	200.9 / 6010B	10	1[b]	2
Vanadium	7440-62-2	200.7 / 6010B	50	10	1
Zinc	7440-66-6	200.7 / 6010B	20	10	2

Notes:
aa - Target Analyte List (TAL) Metals, from *CLP Inorganic Analytical Statement of Work*, ILM04.0.
a - *Methods for Chemical Analysis of Water & Wastes* / SW-846 analytical methods.
b - Method Detection Limit is given.
c - PQL; Practical Quantitation Limit established by the laboratory.
e - CRQL, Contract Required Quantitation Limit.

TABLE QAPP - 1.3
GENERAL CHEMISTRY
Soil and Water Quality Criteria and Field Parameter Summary

Type	Analytes	CAS #	Method[a]	Laboratory Water MDL[b] ug/L	Inorganics ILM04.0 CRQL[c] Water ug/L	Laboratory Soil MDL[b] mg/Kg
Miscellaneous	Cyanide, (Total)	57-12-5	EPA 335.2	50	10	1
Wet Chemistry	Cation Exchange Capacity	-	EPA 9081	-	-	0.005 meq/gm
Wet Chemistry	Alkalinity (CaCO3)	-	EPA 310.2	100 ($CaCO_3$)	-	-
	Ammonia as N	-	EPA 350.3	100		
Wet Chemistry	Chloride	-	EPA 300.0	200	-	-
Wet Chemistry	Fluoride	-	EPA 300.0	100	-	-
Wet Chemistry	Nitrate	-	EPA 300.0	50	-	-
Wet Chemistry	Nitrite	-	EPA 300.0	50	-	-
	Ortho- Phosphate	-	EPA 300.0	200	-	-
Wet Chemistry	Sulfate	-	EPA 300.0	300	-	-
Wet Chemistry	Sulfide	-	EPA 376.1	1000	-	-
Wet Chemistry	Carbonate	-	SM2320B	20	-	-
Wet Chemistry	Bicarbonate	-	SM2320B	20	-	-
Wet Chemistry	Total Dissolved Solids	-	EPA 160.1	10 mg/L	-	-
Wet Chemistry	Total Suspended Solids	-	EPA 160.2	10 mg/L	-	-
Wet Chemistry	Total Organic Carbon	-	EPA 415.1 / 9060	1000	-	-
	Analytes		Field Method	Sensitivity		
Field Parameter	pH	-	EPA 150.1	0.05 units	-	-
Field Parameter	Specific Conductance	-	EPA 120.1	5 mhos	-	-
Field Parameter	Dissolved Oxygen	-	EPA 360.1	1 mg/L	-	-
Field Parameter	Temperature	-	S.M. 2550	0.5 units	-	-
Field Parameter	Oxidation Reduction (Eh)	-	S.M. 2580	+/- 10 mV	-	-
Field Parameter	Turbidity	-	EPA 180.1	1 NTU	-	-

NOTES:
a - *Methods for Chemical Analysis of Water & Wastes*, *Standard Methods*, and SW-846 analytical methods.
b - MDL: Method Detection Limit.
c - CRQL, Contract Required Quantitation Limit.

TABLE QAPP-1.4
SEMI-VOLATILE
Soil and Water Quality Criteria

Type	Analytes	CAS #	Method	Laboratory Water RL ug/L	CLP Organics OLM04.2 CRQL Water ug/L	CLP Organics OLM04.2 CRQL Soil mg/Kg
Acids	2,4,5-Trichlorophenol	95-95-4	8270C	10	25	0.83
Acids	2,4,6-Trichlorophenol	88-06-2	8270C	10	10	0.33
Acids	2,4,Dinitrophenol	51-28-5	8270C	10[d]	25	0.83
Acids	2,4-Dichlorophenol	120-83-2	8270C	10	10	0.33
Acids	2,4-Dimethylphenol	105-67-9	8270C	10	10	0.33
Acids	2-Chlorophenol	95-57-8	8270C	10	10	0.33
Acids	2-Nitrophenol	88-75-5	8270C	10	10	0.33
Acids	4,6-Dinitro-o-cresol	534-52-1	8270C	50	25	0.83
Acids	4-Nitrophenol	100-02-7	8270C	0.1	25	0.83
Acids	2-Methylphenol, (o-Cresol)	95-48-7	8270C	10	10	0.33
Acids	p-Chloro-m-cresol, (4-chloro-3-methyl phenol)	59-50-7	8270C	10	10	0.33
Acids	4-Methylphenol, (p-Cresol)	106-44-5	8270C	10	10	0.33
Acids	Pentachlorophenol	87-86-5	8270C	0.1	25	0.83
Acids	Phenol	108-95-2	8270C	10	10	0.33
Base/Neutral	2,2'-oxybis(1-chloropropane)	108-60-1	8270C	10	10	0.33
Base/Neutral	2,4-Dinitrotoluene	121-14-2	8270C	10	10	0.33
Base/Neutral	2,6-Dinitrotoluene	606-20-2	8270C	10	10	0.33
Base/Neutral	2-Chloronaphthalene, (beta-chloronaphthalene)	91-58-7	8270C	10	10	0.33
Base/Neutral	2-Methylnaphthalene	91-57-6	8270C	10	10	0.33
Base/Neutral	2-Nitroaniline	88-74-4	8270C	50	25	0.83
Base/Neutral	3,3-Dichlorobenzidine	91-94-1	8270C	50	10	0.33
Base/Neutral	3-Nitroaniline	99-09-2	8270C	50	25	0.83
Base/Neutral	4-Bromophenyl phenyl ether	101-55-3	8270C	10	10	0.33
Base/Neutral	4-Chloroaniline	106-47-8	8270C	10	10	0.33
Base/Neutral	4-Chlorophenyl phenyl ether	7005-72-3	8270C	10	10	0.33
Base/Neutral	4-Nitroaniline	100-01-6	8270C	50	25	0.83
Base/Neutral	Acenaphthene	83-32-9	8270C	10	10	0.33
Base/Neutral	Acenaphthylene	208-96-8	8270C	10	10	0.33
Base/Neutral	Acetophenone	98-86-2	8270C	10	10	0.33
Base/Neutral	Anthracene	120-12-7	8270C	10	10	0.33
Base/Neutral	Benzo(a)anthracene	56-55-3	8270C	0.01[e]	10	0.33
Base/Neutral	Benzo(a)pyrene	50-32-8	8270C	10	10	0.33
Base/Neutral	Benzo(b)fluoranthene	205-99-2	8270C	10	10	0.33
Base/Neutral	Benzo(g,h,i)perylene	191-24-2	8270C	10	10	0.33
Base/Neutral	Benzo(k)fluoranthene	207-08-9	8270C	10	10	0.33
Base/Neutral	bis(2-chloroethoxy)methane	111-91-1	8270C	10	10	0.33
Base/Neutral	bis(2-chloroethyl)ether	111-44-4	8270C	10	10	0.33

TABLE QAPP-1.4

SEMI-VOLATILE

Soil and Water Quality Criteria

Type	Analytes	CAS #	Method	Laboratory Water RL	CLP Organics OLM04.2 CRQL Water	CLP Organics OLM04.2 CRQL Soil
				ug/L	ug/L	mg/Kg
Base/Neutral	bis(2-ethylhexyl)phthalate, (DEHP)	117-81-7	8270C	2[d]	10	0.33
Base/Neutral	Butyl benzyl phthalate	85-68-7	8270C	10	10	0.33
Base/Neutral	Chrysene	218-01-9	8270C	0.01[e]	10	0.33
Base/Neutral	Dibenz[a,h]anthracene	53-70-3	8270C	10	10	0.33
Base/Neutral	Dibenzofuran	132-64-9	8270C	10	10	0.33
Base/Neutral	Diethyl phthalate	84-66-2	8270C	10	10	0.33
Base/Neutral	Dimethyl phthalate	131-11-3	8270C	10	10	0.33
Base/Neutral	Di-n-butyl phthalate	84-74-2	8270C	10	10	0.33
Base/Neutral	Di-n-octylphthalate	117-84-0	8270C	10	10	0.33
Base/Neutral	Fluoranthene	206-44-0	8270C	10	10	0.33
Base/Neutral	Fluorene	86-73-7	8270C	10	10	0.33
Base/Neutral	Hexachlorobenzene	118-74-1	8270C	10	10	0.33
Base/Neutral	Hexachlorobutadiene	87-68-3	8270C	10	10	0.33
Base/Neutral	Hexachlorocyclopentadiene	77-47-4	8270C	50	10	0.33
Base/Neutral	Hexachloroethane	67-72-1	8270C	10	10	0.33
Base/Neutral	Indeno[1,2,3-cd]pyrene	193-39-5	8270C	10	10	0.33
Base/Neutral	Isophorone	78-59-1	8270C	10	10	0.33
Base/Neutral	Naphthalene	91-20-3	8270C	10	10	0.33
Base/Neutral	Nitrobenzene	98-95-3	8270C	10	10	0.33
Base/Neutral	N-Nitrosodi-n-propylamine	621-64-7	8270C	10	10	0.33
Base/Neutral	N-Nitrosodiphenylamine	86-30-6	8270C	10	10	0.33
Base/Neutral	Phenanthrene	85-01-8	8270C	10	10	0.33
Base/Neutral	Pyrene	129-00-0	8270C	10	10	0.33

Notes:

aa - Target Compound List analytes, from *Contract Laboratory Program (CLP) Organic Analytical Statement of Work*.(OLM04.2).

a - USEPA Methods from SW-846.

b - Reporting Limits are Practical Quantitation Limits (PQL) unless otherwise noted, established by participating laboratory.

c - CRQL, Contract Required Quantitation Limit.

d - Laboratory reporting limit is a Method Detection Limit (MDL) established annually for each instrument. Values are qualified as estimated up to 5 times the indicated number.

e - Laboratory reporting limit is established by special sample preparation procedures. Matrix interferences may render this reporting limit unachievable. Values reported are qualified as estimated up to a laboratory PQL of 10 ug/L.

TABLE QAPP -1.5
PESTICIDE/ PCBs
Soil and Water Quality Criteria

Analytes[aa]	CAS #	Method[a]	Laboratory Water PQL[b]	CLP Organics OLM04.2 CRQL[c] Water	Laboratory Soil PQL[b]	CLP Organics OLM04.2 CRQL[c] Soil
			ug/L	ug/L	mg/Kg	mg/Kg
4,4'-DDD	72-54-8	8081A	0.02	0.1	0.002	0.0033
4,4'-DDE	72-55-9	8081A	0.02	0.1	0.002	0.0033
4,4'-DDT	50-29-3	8081A	0.02	0.1	0.002	0.0033
Aldrin	309-00-2	8081A	0.01	0.05	0.001	0.0017
alpha-BHC	319-84-6	8081A	0.01	0.05	0.001	0.0017
beta-BHC	319-85-7	8081A	0.01	0.05	0.001	0.0017
delta-BHC	319-86-8	8081A	0.01	0.05	0.001	0.0017
Dieldrin	60-57-1	8081A	0.02	0.1	0.002	0.0033
Endosulfan I	959-98-8	8081A	0.01	0.05	0.001	0.0017
Endosulfan II	33213-65-9	8081A	0.02	0.1	0.002	0.0033
Endosulfan sulfate	1031-07-8	8081A	0.02	0.1	0.002	0.0033
Endrin	72-20-8	8081A	0.02	0.1	0.002	0.0033
Endrin aldehyde	7421-93-4	8081A	0.02	0.1	0.002	0.0033
gamma-BHC, (lindane)	58-89-9	8081A	0.01	0.05	0.001	0.0017
Heptachlor	76-44-8	8081A	0.01	0.05	0.001	0.0017
Heptachlor epoxide	1024-57-3	8081A	0.01	0.05	0.001	0.0017
Methoxychlor	72-43-5	8081A	0.1	0.5	0.01	0.017
Toxaphene	8001-35-2	8081A	1	5	0.1	0.17
Aroclor 1016	12674-11-2	8082	0.1	1	0.01	0.033
Aroclor 1221	11104-28-2	8082	0.2	2	0.02	0.067
Aroclor 1232	11141-16-5	8082	0.1	1	0.01	0.033
Aroclor 1242	53469-21-9	8082	0.1	1	0.01	0.033
Aroclor 1248	12672-29-6	8082	0.1	1	0.01	0.033
Aroclor 1254	11097-69-1	8082	0.1	1	0.01	0.033
Aroclor 1260	11096-82-5	8082	0.1	1	0.01	0.033

Notes:
aa - Target Compound List analytes from *Contract Laboratory Program (CLP) Organic Analytical Statement of Work* (OLM04.2).
a - USEPA Methods from SW-846.
b - Reporting Limits are Practical Quantitation Limits (PQL) unless otherwise noted, established by participating laboratory.
c - CRQL, Contract Required Quantitation Limit.

TABLE QAPP-2

Golder Technical and Quality Control Procedures

TP 1.1-14	Land Seismic Refraction Survey
TP 1.2-2	Geotechnical Rock Core Logging
TP-1.2-6	Field Identification of Soil
TP 1.2-17	Rising Head Slug Test
TP-1.2-18	Sampling Surface Soil for Chemical Analysis
TP-1.2-21	Geotechnical Test Pit Logging and Sampling
TP-1.2-23	Chain of Custody
TP-1.2-26	Surface Water Sampling Methods
TP-1.3-1	Geologic Mapping of Soils in Test Pits
TP-1.4-6a	Manual Groundwater Level Measurement
TP-2.2-12	Analytical Data Management
TP-8.2-3	Sediment Sampling
TP-8.6-1	Benthic Invertebrate Sampling Procedures
QP-11.1	Calibration and Maintenance of Measuring and Test Equipment
QP-14.1	Corrective and Preventive Action
QP-16.1	Quality Assurance Records Management

TABLE QAPP-2 (continued)

Other Technical and Quality Control Procedures

223	GPS Calibration
224	GPS Operation
376-6	Portable Survey Instrument Operability Checks
378-2	Calibration Check of Vendor-Calibrated Portable Survey Meters
379-2	Calibration of the Ludlum Scaler Ratemeter, Model 2221

ASTM Technical Procedures for Biota

D4557-85 Standard Practice for Collecting Benthic Macroinvertebrates with Surber and Related Type Samplers

E2122-02 Standard Guide for Conducting In-situ Field Bioassays With Caged Bivalves

TABLE QAPP-3

Surface & Groundwater Sample Container Types, Volumes, Handling, Preservation, and Holding Times

Analytes	Container Type	Special Handling	Preservation	Maximum Holding Time
Radiochemical Compounds	1, 1000 mL narrow mouth polyethylene bottle	Fill to Neck..	HNO_3, pH < 2, store at <4°C.	6 months
Semi volatile Organic Compounds	1, 1,000 mL narrow mouth amber glass bottles, teflon-lined cap.	Fill to neck, (Collect an additional 1,000 mL aliquot for MS/MSD analysis if required)	None. Store in dark at <4°C.	14 days for extraction, 40 days for analysis after extraction
Pesticide/PCBs	1, 1,000 mL narrow mouth amber glass bottles, teflon-lined cap.	Fill to neck, (Collect an additional 1,000 mL aliquot for MS/MSD analysis if required)	None. Store in dark at <4°C.	14 days for extraction, 40 days for analysis after extraction
pH, Temperature, Ox-Redox, Conductivity, Dissolved Oxygen, Turbidity	Field Parameters; Sample is not collected	Field Parameters; Sample is not collected	Field Parameters; Sample is not collected	Field Parameters; Sample is not collected
Alkalinity, Chloride, Sulfate, Total Dissolved Solids, Total Organic Carbon	1, 1000 mL narrow mouth polyethylene bottle	Fill to neck	Alk., Cl, SO4, TDS; None, store at <4°C TOC; HCl to pH <2	TDS, 7 days Alk.; 14 days Cl, SO4, TOC;, 28 days
Dissolved Metals, Mercury	1, 1000 mL narrow mouth polyethylene bottle.	Filter through 0.45 um membrane filter, fill to neck.	HNO_3, pH < 2, store at <4°C.	6 months, (28 day, Hg)
Total Metals, Mercury	1, 1000 mL narrow mouth polyethylene bottle.	Fill to neck	None, store at <4°C	6 months, (28 day, Hg)

TABLE QAPP-4

Soil & Sediment Sample Container Types, Volumes, Handling, Preservation, and Holding Times

Analytes	Container Type	Special Handling	Preservation	Maximum Holding Time
Radiochemical Compounds	1, 4 oz. Wide mouth soil jar	Fill completely	None, store in dark at 4°C.	6 months
Semi volatile Organic Compounds	1, 4 oz. Wide mouth soil jar	Fill completely	None, store in dark at 4°C.	14 days for extraction, 40 days for analysis after extraction
Pesticide/PCBs	1, 4 oz. Wide mouth soil jar	Fill completely	None, store in dark at 4°C.	14 days for extraction, 40 days for analysis after extraction
Metals	1, 4 oz. Wide mouth soil jar	Fill completely	None, store in dark at 4°C.	6 months
Mercury	1, 4 oz. Wide mouth soil jar	Fill completely	None, store in dark at 4°C.	28 days